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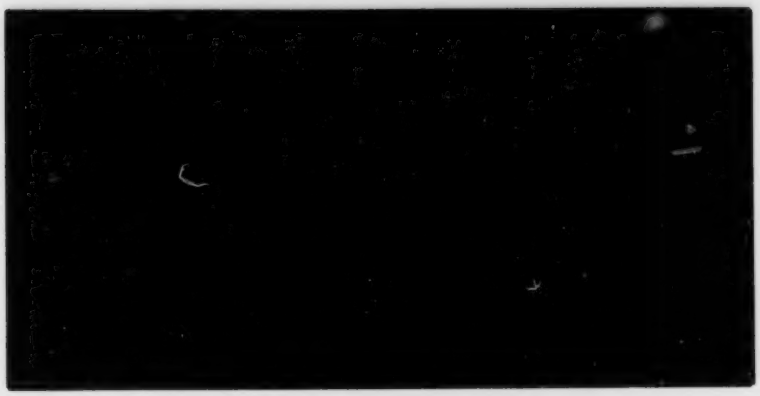

SWEEP

SOIL AND WATER

ENVIRONMENTAL

ENHANCEMENT PROGRAM

PAMPA

PROGRAMME D'AMELIORATION

DU MILIEU PEDOLOGIQUE

ET AQUATIQUE

Canada

Ontario

SWEEP

is a $30 million federal-provincial agreement, announced May 8, 1986, designed to improve soil and water quality in southwestern Ontario over the next five years.

PURPOSES

There are two interrelated purposes to the program; first, to reduce phosphorus loadings in the Lake Erie basin from cropland run-off; and second, to improve the productivity of southwestern Ontario agriculture by reducing or arresting soil erosion that contributes to water pollution.

BACKGROUND

The Canada-U.S. Great Lakes Water Quality Agreement called for phosphorus reductions in the Lake Erie basin of 2000 tonnes per year. SWEEP is part of the Canadian agreement, calling for reductions of 300 tonnes per year — 200 from croplands and 100 from industrial and municipal sources.

PAMPA

est une entente fédérale-provinciale de 30 millions de dollars, annoncée le 8 mai 1986, et destinée à améliorer la qualité du sol et de l'eau dans le Sud-ouest de l'Ontario.

SES BUTS

Les deux buts de PAMPA sont: en premier lieu de réduire de 200 tonnes par an d'ici 1990 le déversement dans le lac Erie de phosphore provenant des terres agricoles, et de maintenir ou d'accroître la productivité agricole du Sud-ouest de l'Ontario, en réduisant ou en empêchant l'érosion et la dégradation du sol.

SES GRANDES LIGNES

L'entente entre le Canada et les États-Unis sur la qualité de l'eau des Grands Lacs prévoyait de réduire de 2 000 tonnes par an la pollution due au phosphore dans le bassin du lac Erie. PAMPA fait partie de cette entente qui réduira cette pollution de 300 tonnes par an — 200 tonnes provenant des terres agricoles et 100 tonnes provenant de sources industrielles et municipales.

CROPPING, TILLAGE

AND

LAND MANAGEMENT

PRACTICES IN SOUTHWESTERN ONTARIO

1986

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1.0 EXECUTIVE SUMMARY

This report represents the results of a survey conducted on 1,115 farms in southwestern Ontario in the fall of 1986. The purpose of the survey was to provide a detailed data base for the Soil and Water Environmental Enhancement Program (SWEEP). SWEEP is a 5-year program to reduce phosphorus loadings in the Lake Erie Basin from cropland run-off and to improve the productivity of agriculture. The survey gathered information on cropping, tillage, fertilization and land management practices in 13 counties and regional municipalities of the SWEEP study area. All of these factors impact on phosphorus delivery in the Lake Erie watershed. This data was compiled to serve as a benchmark against which future progress in the implementation of soil and water conservation programs might be evaluated at the conclusion of the SWEEP Agreement.

The survey was conducted by means of a personal interview questionnaire, which was designed by the SWEEP Land Management and Cropping Practices Working Group, the membership of which is included as Appendix A. A draft questionnaire was reviewed by a cross-section of individuals involved in soil conservation work, and was pretested with a number of farmers. The final survey questionnaire involved 40 different questions and required 45 minutes to one hour to be completed. Most of the data was recorded on a field by field basis for each farm.

The sample drawn for the personal interviews was stratified on the basis of county or regional municipality, township, and erosion category. Based on 141 townships originally in the survey, 10 completed interviews was set as the target to maintain statistical reliability. The final stratification into soil loss erosion category (high/low) allowed the

study area to be divided into areas where soil losses were above and below tolerable levels.

Survey results were compiled on a county and regional municipality basis. The many factors analyzed included general information relating to farms in the study area; erosion control practices; various tillage and planting operations; systematic, random and natural drainage; and manure, nitrogen and phosphorus applications. To assess the representativeness of the results, the information was compared to crop acreages as reported in Agricultural Statistics for Ontario (1985), Census of Agriculture (1981) data, and the 1984 study of Cropping, Tillage and Land Management Practices in Southwestern Ontario by Wall, Vaughan and Driver. Since a high degree of similarity exists between the results of the current survey and the information included in the above reference sources, it is possible to extrapolate findings to the county or regional municipality level.

Cash crop farming enterprises (43%) predominated in the SWEEP study area with five counties, Brant, Elgin, Kent, Essex and Lambton having more than half of their farms in this category. This was followed by dairy (18%) and mixed farms (12%).

Swine, poultry, sheep, fruit and vegetables and tobacco together comprised over 18% of the study area. Results showed that the most common size of farm operation was 40-99 hectares (37% of responses) while the most predominate age category of operator was 45-54 (29%). Moreover, the predominant number of years the survey site had been farmed was within the 11-20 year category.

The principal crop grown in the study area was corn (36%), followed by beans (20%), forages (17%), fall cereals (12%), spring cereals (11%), fruits and vegetables (2%), and tobacco (slightly greater than 1%). Crop rotations were grouped into 6 categories based on combinations of row crops, cereals, forage, and pasture. Contrary to popular perception, only 1% of farm fields had no rotation at all. Rotations involving only row crops occurred 10% of the time. Forty percent of the fields surveyed contained a rotation of row crops, cereal and forage. In the 21% of the fields where a cropping change occurred within the last five years the main reasons for change were: economic (15%); reduction of erosion and better crop rotation (14%) each; and a change in crops, enterprise or land base (12%).

Survey results showed that only 3% of fields were strip cropped. Plowdown crop results showed only a 16% positive response rate. Three percent of the responses indicated the use of field borders. Land management control practices results showed that permanently vegetated buffer strips were the most common practice (23%), followed by erosion control structures (15%), streambank stabilization and tree windbreaks, each at (14%). Reforestation occurred least frequently, being reported only 8% of the time.

Farmers were asked to state the type of tillage equipment, timing of tillage, tillage depth and tillage direction employed on their fields. The moldboard plough (74%) and fall tillage (73%) are still common practices. It is encouraging to note the use of the modified moldboard plough, the disc/coulter and chisel plough. Their use, however, varied considerably from county to county.

Study results showed that most fields (61%) were primary tilled to a depth of 11-15 cm, while few (1%) were ploughed to depths greater than 26cm. However, it was surprising to note that a significant proportion of the fields were primary tilled at shallow depths (18%). Very little consideration for slope was given when ploughing. The direction most frequently ploughed (63%) was not related to slope. Contour ploughing occurred on only 5% of study area fields. The highest number of fields being contour ploughed were in Haldimand-Norfolk (12%) and Huron (11%).

Seedbed preparation (secondary tillage) methods were employed most often between March and May (85%). The most prevalent type of seedbed implements were the cultivator (49%) and disc and harrows (30%). Seedbed tillage was most often done twice. The most common reason for repeated tillage was that the seedbed was not fine enough. Approximately 20% of farmers have changed tillage practices in the last 5 years. Based on those who have changed, 30% gave the primary reason for change as a desire to reduce erosion. Additional reasons were changing crops, equipment or land base (19%) and to reduce cost (16%).

In the study area the most common type of planting equipment used was the row crop planter (45%) and the seed drill (46%). Modified row crop planters and seed drills, used to plant in heavy residue, were each used in only 1% of the fields of the study area.

Results showed that most farmers also tended to plant without consideration for the effects of slope (61%). A significant proportion (16%) plant up and down the major slope.

Results relating to systematic, random and natural tile drainage showed that systematic drainage frequently occurred in 5-10 hectare installations (33%). Randomly installed tile drainage most frequently occurred in small installations and least frequently in large installations. Natural drainage followed the same pattern. Forty-eight percent of responses indicated naturally drained areas being 1-4 hectares in size. Naturally drained areas of 21-40 hectares occurred only 6% of the time.

The use of manure, method of application, timing of application and the timeliness of its incorporation into the soil are all pertinent factors in understanding the potential effects upon water quality. In the SWEEP study area less than 40% of the responses indicated that manure was applied. Of those farms on which manure was spread, 83% of the fields were spread using a tractor and spreader. Responses indicated that 77% of the manure was applied during the spring, summer and fall. Only 9% of the respondents indicated they spread manure during the winter, while 14% indicated it was spread all year long. A cross tabulation of manure application with type of farm operation revealed that in the case of year round applications, dairy farmers accounted for (46%) followed by mixed (22%) and beef operations (15%). Where winter applications occurred, 34% were made by dairy operations, 23% by hog operations and 20% by mixed farm operations.

A review of the manure incorporation in the study area showed that approximately 30% of the time manure was spread onto forage crops. In only 14% of the responses was manure incorporated within the recommended 24 hour period. Almost one-third (32%) of the responses indicated that manure was not incorporated for more than three days.

Data on some 3,800 fields revealed that nitrogen fertilizer was applied on the basis of the farmer's experience (48%) and on the basis of a soil test recommendation within the previous year (27%). Applications of nitrogen were highest in the spring (88%) with little variation by county with respect to timing of applications. The principal method of nitrogen application was broadcasting (49%).

Forty-eight percent of the responses about phosphorus, the main nutrient of interest in the improvement of Great Lakes water quality, revealed it was applied based on experience. Twenty-eight percent of the applications were made on the basis of soil test within the previous year while 24% of the fields on the study area did not receive phosphorus applications. Applications of phosphorus were highest in the spring (83%). An average of 13% of the responses indicated fall applications, while 4% of the responses indicated both spring and fall. Two methods of phosphorus applications accounted for 95% of phosphorus applications: 48% of the responses indicated broadcasting was used, while 47% indicated application through the planter.

When farmers were asked questions concerning erosion control measures on their farms, fifteen percent indicated that erosion control measures were present. Most often the control measures had been privately funded.

The sources of information on soil erosion or conservation were farm publications (81%), radio and T.V. (65%), OMAF news (61%), books or journals (34%), and research institutes or universities (22%).

Earlier studies of erosion and sediment transport by the Lands Directorate, Environment Canada and the Ontario Institute of Pedology coupled with the compatible data from this survey can allow estimation of soil loss at the farm level and the whole study area by employing the Universal Soil Loss Equation (USLE). It can also be used to estimate the reduction in soil erosion as a result of changed cropping and management practices.

This report contains only the highlights of the extensive data collected through this survey. This data base will enable additional analyses and comparisons to be made and will be used to evaluate several aspects of the SWEEP program.

2.0 BACKGROUND

2.1 The Situation

Ontario soils are among the most productive in Canada. However, soil scientists have identified the following four major processes which reduce the ability to sustain productivity of Ontario soils (Report to the Working Group on Soil & Water Conservation and Development, July 1986):

1. A progressive loss of soil organic matter: massive expansion of row crop production, especially corn and soybeans, and the accompanying disappearance of livestock from a large number of farms have resulted in the de-emphasizing of "soil building" crops (forages, pastures and small grains) that are no longer rotated with row crops.

2. Soil structure deterioration and soil compaction: in addition to the loss of organic matter, a result of the changing thrust in food production has been a move toward specialized and often heavier field equipment, sometimes excessive tillage operations, the tillage of wet soil, and large fields with longer slopes. The first three situations interfere with the function of subsurface drainage systems, aggravate problems of poor soil structure and increase compaction; the last increases soil erosion.

3. Topsoil erosion: a decline in natural fertility and soil organic matter levels has led to accelerated surface runoff and

erosion losses. This also results from the removal of fence rows and woodlots and the often accompanying creation of fields with longer slopes.

4. Reduced available water retained in the soil: little protective soil cover has accelerated surface runoff and increased sheet and gully erosion.

2.2 The Costs of Erosion and Effects on Productivity

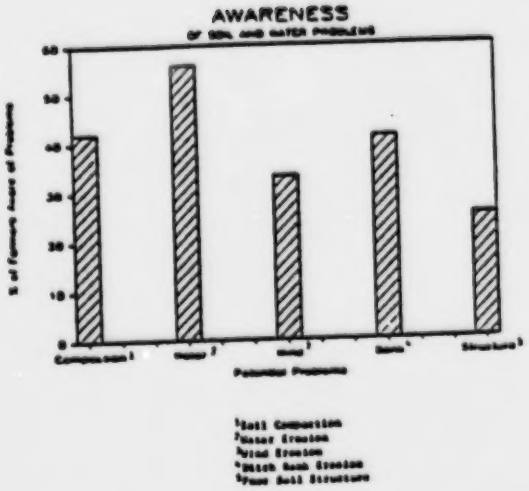
Economic losses that have been attributed to soil erosion include: reduced yield, lost soil nutrients and pesticides, soil degradation, increased energy costs, sedimentation of drainage ditches, dissected fields and reduced operational efficiency (Wall, G.J. and Driver G.A., 1982). All these damages are recognizable but difficult to cost. However for factors that have been quantified, "annual cropland soil erosion costs in Ontario are estimated to be $68 million from yield reduction and nutrient/pesticide losses. An additional $6 million is estimated as the annual cost of maintaining surface and subsurface drainage systems." (Ontario Institute of Agrologists, 1983).

According to their report, annual costs of soil erosion were greatest in southern and western Ontario respectively while lower losses occurred in the central and eastern regions of the province. The greatest costs on a county basis have occurred in Elgin, Kent, Huron, Middlesex, and Oxford counties. These were closely followed by Brant, Lambton, Perth, Simcoe, and Wellington counties, and the regional municipalities of Haldimand-Norfolk, Waterloo and York.

Erosion effects are direct and indirect. Direct effects are the washing out of seeds and nutrients, deposition of sediment on newly established seedlings, and gullying. An indirect effect is the long-term decrease in soil productivity. Erosion removes the rich surface horizon of soil leaving subsoils as the cultivation media. Subsoils have lower water storage capacities, poorer infiltration, poorer structure, lower fertility, and generally less desirable characteristics as a rooting medium than surface soil. There is no single remedial measure that will be effective in restoring productivity. For example, fertilizer can restore productivity on eroded soils on which fertility is the only yield limitation but this is rarely the case. Other factors such as lower infiltration rates and poorer structure represent long-term limitations to productivity that may take years to correct. Erosion control programs have to be tailored to individual soils and management systems.

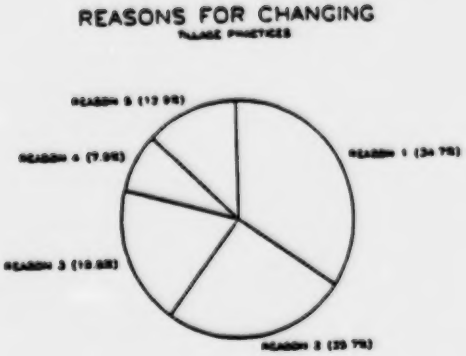
2.3 Progress Toward Improvement

Most farmers perceive themselves as stewards of the land and want to protect and maintain the heritage of the soil. A 1984 study by Wall, G.J., Vaughan, E.E. and G.A. Driver, showed that farmers were quite aware of soil and water problems (Figure 1) and were changing their management practices in recognition of them. Figure 2 from their report, shows a change in tillage practices to help reduce soil erosion, and Figure 3 indicates that over 50% of farmers were employing tile outlet protection and leaving buffer strips. This concurs with a soil conservation survey (Ontario Institute of Agrologists, 1983) which found that 89% of the respondents indicated that soil erosion was a concern.



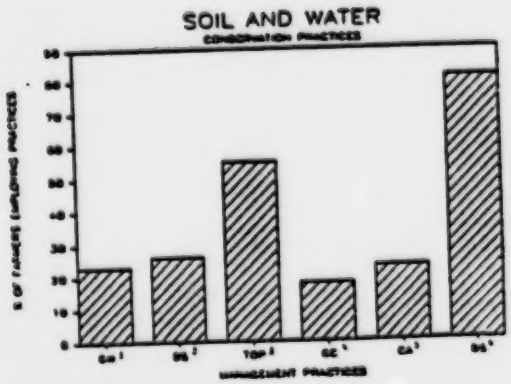
[1]Soil Compaction
[2]Water Erosion
[3]Wind Erosion
[4]Silt Sand Erosion
[5]Poor Soil Structure

Figure 1: Awareness of Soil and Water Problems



Reason 1 - Reduce erosion.
Reason 2 - Maintain or build soil structure.
Reason 3 - Reduce production costs.
Reason 4 - Improve yields.
Reason 5 - Change crops/equipment.

Figure 2: Reasons for Changing Tillage Practices



[1]Grass Waterway
[2]Crop Structure
[3]Tile Outlet Protection
[4]Gully Control
[5]Cattle Access
[6]Buffer Strip

Figure 3: Soil and Water Conservation Practices

2.4 Research, Monitoring and Technology Transfer

Action has been taken to address the above concerns and practices. In May 1986, a 5-year, $30 million agreement between the provincial and federal government, the Soil and Water Environmental Enhancement Program (SWEEP) was established. The two interrelated purposes of this program are:

1) to reduce phosphorus loadings in the Lake Erie basin from cropland run-off;
2) to improve soil productivity by reducing or arresting soil erosion.

Under SWEEP, Agriculture Canada is responsible for research, including pilot watershed studies, technology evaluation and development and socio-economic effects of conservation measures on individual farms. The Ministry of the Environment and Environment Canada are providing supportive monitoring services for SWEEP. The Ontario Ministry of Agriculture and Food provides technical assistance, on-farm demonstrations and grants to financially assist farmers in the SWEEP area. This program contains a public information component supported by all participating agencies.

3.0 INTRODUCTION

3.1 Study Rationale

Soil erosion, sediment delivery to watercourses, and potential phosphorus loads from land use activities were documented in reports by the Pollution from Land Use Activities Reference Group (PLUARG) of the International Joint Commission (IJC). The Canada-U.S. Great Lakes Water Quality Agreement calls for an annual phosphorus reduction in the Lake Erie Basin of 2000 tonnes by 1990. The Canada-Ontario Agreement on Great Lakes Water Quality calls for a reduction of 300 tonnes. To achieve this, a reduction target of 200 tonnes from agricultural cropland sources and 100 tonnes from industrial and municipal sources has been set as the goal to be met by the year 1990. SWEEP has been designed to achieve the reduction of 200 tonnes of phosphorus from cropland during this relatively short time.

For SWEEP to be able to determine when the reduction in phosphorus loadings has been achieved in the Lake Erie Basin, an assessment of the state of cropping, tillage, planting, land management practices, and fertilizer use is required to establish base line conditions. This survey was designed to provide this information.

SWEEP will monitor progress during the latter part of the Agreement to establish changes in the use and location of the above practices. With this base line established subsequent studies will identify the adoption rate of conservation practices. Knowing this, a calculation can be made to determine the phosphorus reduction in the Lake Erie Basin.

3.2 Definition of The Study Area

The following definition was used by the SWEEP Land Management and Cropping Practices Working Group to provide an operational definition of those areas included in the study. The area studied included the counties of Essex, Kent, Lambton, Huron, Perth, Middlesex, Elgin, Oxford, Brant, and the Regional Municipalities of Waterloo and Haldimand-Norfolk. All of the townships of Wellington were included except Minto, Arthur, West Luther, and Eramosa. In Hamilton-Wentworth, the townships of Glanbrook and Ancaster were included. The extent of the SWEEP study area is shown in Figure 4.

3.3 Goals and Objectives

The goal of this study was to collect data on farm crop rotations, tillage practices and fertilization, all of which impact on phosphorus delivery in the Lake Erie watershed. This data will serve as a benchmark against which the effect of implementing soil and water conservation programs can be evaluated at the conclusion of the SWEEP agreement. Most of the survey data was recorded on a field by field basis. The following objectives derived from this goal were to:

1) Measure the area of cropland under various combinations of crops.
2) Compile data on the first system of tillage used after the 1985 crop harvest, including type of tillage machine(s) used, time of year, depth of tillage, and direction of tilling in relation to slope.

SWEEP
STUDY
AREA

Figure 4

3) Compile data on seedbed tillage practices, including tillage machine(s) used on each field, time of year, times tilled, reason for re-tilling and depth of tillage.

4) Record planting practices used in each field including type of machine, time of planting, times tilled, and direction of planting.

5) Record different land management practices in place such as run-off control structures, ditch or stream bank stabilization, permanently vegetated buffer strips along ditches or stream banks, tree windbreaks, and reforestation.

6) Record the area of systematic, random or natural tile drainage and,

7) Record rates of application of manure, nitrogen and commercial phosphorus fertilizer.

A survey conducted in 1984 by Wall, G.J., Vaughan, E.E. and G.A. Driver obtained somewhat comparable information from approximately 100 randomly selected farms in each of 12 counties. The information from that study is useful as a basis of comparison for a number of factors collected in the present survey.

4.0 METHODOLOGY

4.1 Drawing The Sample

To assess whether the required reduction of phosphorus from cropland has taken place requires a variety of information. The focus for this survey was on those factors which influence the export of phosphorus from cropland. Thus, the main emphasis was on soil erosion and the transport of phosphorus on eroded soil particles.

It was deemed to be impractical to assess these factors directly for all of the land in the Lake Erie watershed. It was felt that a representative set of information with an adequate degree of precision could be collected by sampling a sub-set of the study area. Those responsible for the survey determined that sampling efficiency could be improved by dividing the random sample into parts or strata corresponding to known distributions within the study area. In this study, it was important that the random sample be representative of the whole study area so that estimates of various tillage practices and conservation measures can be established over the whole study area.

The sample used in the survey was drawn as follows. Stratification was performed on the basis of county or regional municipality, township and erosion category. Based on the 141 townships originally in the survey, 10 completed interviews per township were required to maintain statistical reliability. Knowing that the initial response rate might be low, the sample size was doubled to 20 per township to provide replacements for refused interviews.

The final stratification into erosion category (high/low) was on the basis of work by the Lands Directorate of Environment Canada. The study area was divided into categories which corresponded to those areas where losses were above and below tolerable levels, that is 6.0 tonnes per hectare. For Haldimand-Norfolk R.M. and Huron County, soil loss mapping was not available. Here the sampling distribution with respect to the soil loss tolerance should approximate the true distribution since the farms were randomly selected.

In each township all the lots and concessions were numbered sequentially. The proportion of the township area in the high category and the low category was tabulated. A large block (150) of uniformly distributed random numbers was generated for each township. Each time, the final value of the random number generator seed was saved to be used to generate the next block of random numbers.

Random numbers were selected from the list sequentially. If the random number chosen had not occurred before, the lot and concession was selected. The erosion category of the selected site was added to the total in its category. When the number of samples equalling the township proportion, in either the high or low category, had been achieved in a given erosion category, subsequent choices falling into the same category were rejected and the next random number from the list was used. A sequential interview number was assigned to the twenty selected lots and concessions.

A number of possibilities were discussed to determine which means of collecting the needed information was most suitable. These

options included telephone interviews, mail out and mail back surveys and drop-off and pick-up questionnaires. The complexity of information needed dictated that a personal interview be conducted. The final survey questionnaire involved 40 different questions and required 45 minutes to one hour to be completed.

4.2 Questionnaire Design

The overall objective of the questionnaire design was two fold: to provide basic information on cropping, tillage, planting, fertilization and land management; and to allow the estimation of soil loss. The draft questionnaire was designed by the SWEEP Land Management and Cropping Practices Working Group, which included members from Agriculture Canada, Environment Canada, the Ontario Ministry of the Environment, the Ontario Ministry of Agriculture and Food, and the University of Guelph. The members of the Land Management and Cropping Practices Working Group are listed in Appendix A.

Revisions to the draft questionnaire were made on the basis of comments from OMAF field staff, university researchers and other professionals. A pretest was conducted with a group of approximately 15 farmers from the sample. Modifications were then made to the questionnaire to resolve difficulties farmers had with the formulation of the questions. Because of the size of the questionnaire, it was found to be useful to separate the questions from the bulky form needed to record the responses. Although the interviews still took 45 minutes to one hour to complete, the farmers' initial perception of the size of the task was not distorted by a complex form. The interview questions and questionnaire are included in Appendix B.

Questions were asked regarding which operations were performed, how they were performed, their timing and the equipment involved.

4.3 Preparations For Conducting Interviews

Files for each farm visit were prepared by 2 full-time technicians during the survey period. Each of the files was labelled with the site's interview number, county, township, lot and concession, and was referenced to an aerial photograph which ranged in scale from 1:25,000 to 1:50,000. As stated in section 4.0, twenty randomly drawn sample sites were selected per township. To provide replacements for refused interviews, files were prepared for 13 of 20 farms. The interviewer was instructed to complete 10 interviews from the list of twenty.

Each of the 13 file folders contained a 5 times enlargement sketch of the farm to be visited which was taken from 1981 aerial photographs. Farm properties were also sketched on mylar as an overlay on the aerial photograph itself. These served as a guide and location reference and 'take-off' point for discussion at the beginning of each farm visit. Survey personnel took to the field an accordian file for each township containing 13 interview sites with sketches and questionnaires, aerial photos for these sites, a photocopy of a township map locating the 13 farm sites, and a list of owner names when possible. Knowing the lot and concession of each site, staff obtained the owner's name, time permitting, from the township offices. Some field staff chose to arrange farm interviews directly by calling in at the farm.

In the Regional Municipality of Waterloo, a letter was sent to members of the Mennonite Community in Wellesley and Woolwich Townships. Members of

the Mennonite Community were particularly helpful in providing valuable information to the study.

The survey took 85 field days to complete (August 11 - December 19, 1986). It was coordinated and staffed by 8 survey personnel hired under the Federal government employment development program - "Section 38".

Before any surveying took place, field staff, in particular the first team of interviewers, were given a training session. This session involved a slide-talk presentation on various conservation equipment and land management practices available. The design of the study and how the random sample was chosen in each township was explained to the interviewers. The session ended with each pair of interviewers role playing the role of interviewer and farmer. The pretest field work was conducted in pairs while the survey was done individually.

All survey people were given a letter of introduction. To arrange the interviews, the procedure followed was to search out the operator of a predesignated farm location. This technique proved to be too slow, allowing field staff to only average 8-10 interviews/week/person. This procedure was revised some six weeks into the survey and after consultation with the Land Management and Cropping Practices Working Group.

Interviewers using the revised approach were instructed to make 3 attempts to obtain the interview at the designated location. Upon failure, the interviewer was to obtain an interview with the operator of a farm within 5 lots each side of the designated location within the same concession.

5.0 FINDINGS

5.1 General Information Relating to Farms in the Study Area

Table 1 shows the number of counties and regional municipalities (13), and farms (1,115) surveyed. Across the study area, the number of farms in a county surveyed ranged from a high of 4.3% to a low of 1.9% of the farms. The exception to these rates occurred in Hamilton-Wentworth where only 2 of its townships in the Lake Erie watershed were included in the study. The sample obtained in Hamilton-Wentworth is sufficient to generalize with respect to the two townships, but it is not adequate to draw conclusions about practices in the remainder of Hamilton-Wentworth.

Table 1

Farms Surveyed in the Study Area

County/Region	Number of Farm Interviews	Total • Farms in County	Percent of Farms Surveyed
Brant	23	1227	1.9
Elgin	61	2097	2.9
Essex	96	3088	3.1
Haldimand-Norfolk	97	3899	2.5
Hamilton-Wentworth	14	1553	0.9
Huron	142	3790	3.7
Kent	91	3204	2.8
Lambton	102	3151	3.2
Middlesex	151	3520	4.3
Oxford	106	2724	3.9
Perth	111	3156	3.5
Waterloo	50	1823	2.7
Wellington	71	3219	2.2
Sweep Study Area	1115	36451	3.1

• Statistics Canada, Census of Agriculture, 1981.

A number of general questions relating to the farm were asked to provide information as a basis of comparison with other statistical

information from the Census of Agriculture publications, and crop production information from OMAF publications. Comparisons of this nature are required to establish the degree to which the sample is representative of the entire study area.

The general questions asked in this survey related to type of farm enterprise, livestock populations, size of farm, age of operator and years farmed on the selected parcel.

5.1.1 Farm Enterprise

Farmers were asked their principal type of operation among the following categories: cash crop, beef, dairy, hogs, sheep, poultry, mixed farming, fruit and vegetables, and tobacco. If the farmer felt none of the categories were applicable, a category for other responses was available.

The principal enterprise of the farmers in the SWEEP study area was cash crops (43%) (see Table 2).

Cash Crop Farming

Cash crop farming predominates in the SWEEP study area. Figure 5 shows the distribution by county. Five counties, Brant, Elgin, Kent, Essex and Lambton had more than half of their farms in this category. Essex and Kent had approximately 70% of their farms in cash crops.

Table 2

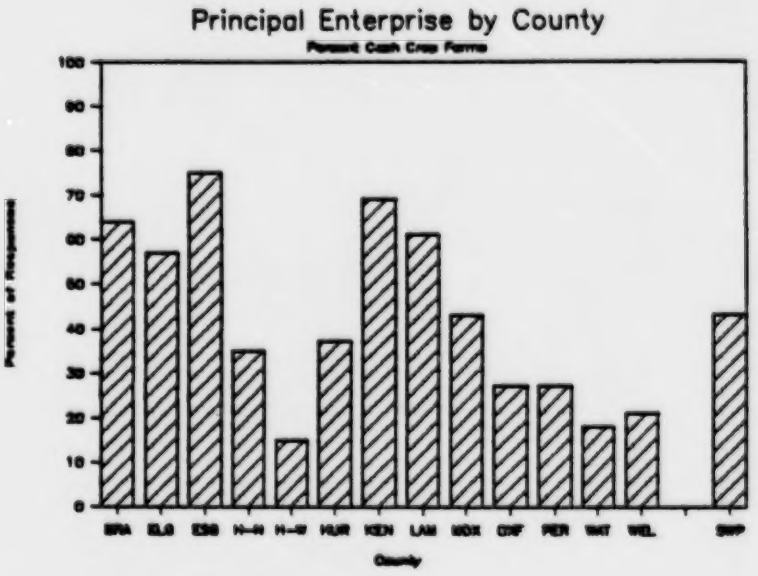
Principal Enterprise
Percent Response by Category

County/Region	Cash Crop %	Beef %	Dairy %	Mixed Farming %	Swine %	Poultry %	Sheep %	Fruit & Vegetables %	Tobacco %
Brant	64	0	18	4	0	0	0	5	9
Elgin	57	3	7	2	7	3	0	3	18
Essex	75	0	8	4	2	0	0	11	0
Haldimand-Norfolk	35	7	10	23	2	1	0	1	21
Hamilton-Wentworth	15	21	36	14	0	0	0	14	0
Huron	37	14	18	14	15	2	0	0	0
Kent	69	1	0	19	9	0	0	1	1
Lambton	61	4	8	10	9	6	0	1	1
Middlesex	43	11	19	16	6	1	0	0	4
Oxford	27	8	37	1	16	0	2	2	7
Perth	27	7	40	2	22	2	0	0	0
Waterloo	18	27	23	15	13	2	0	2	0
Wellington	21	22	26	24	4	2	1	0	0
SWEEP Study Area *	43	9	18	12	9	2	1	2	4

* SWEEP Study Area figures are calculated using the entire 1115 interviews. Figures by county are partitioned into county/region and distributed across the classes in a row.

The percent of cash crop farm operations per county ranged from lows of 15% and 18% in Hamilton-Wentworth Region and Waterloo Regions to a high of 75% in Essex and 69% in Kent County.

Figure 5



Livestock Operations

Dairy farm enterprises which are shown in Figure 6, were prevalent in Perth (40%), Oxford (35%), Wellington (26%),and Waterloo (23%).

Figure 6

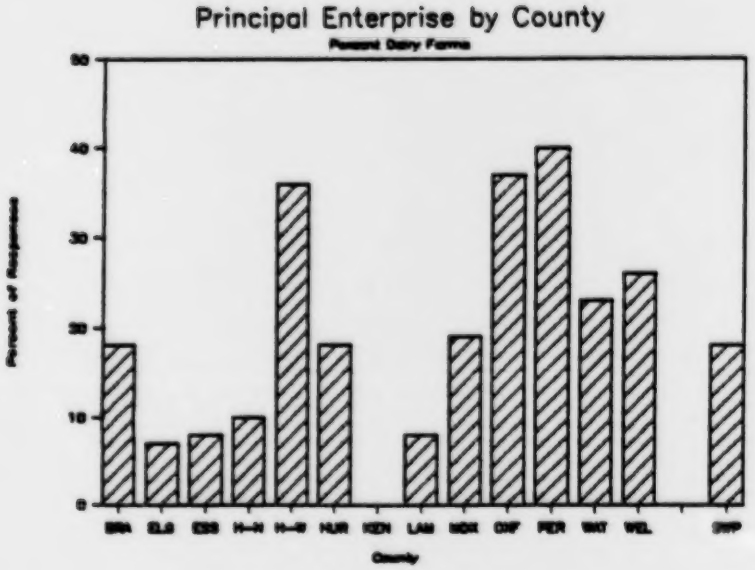
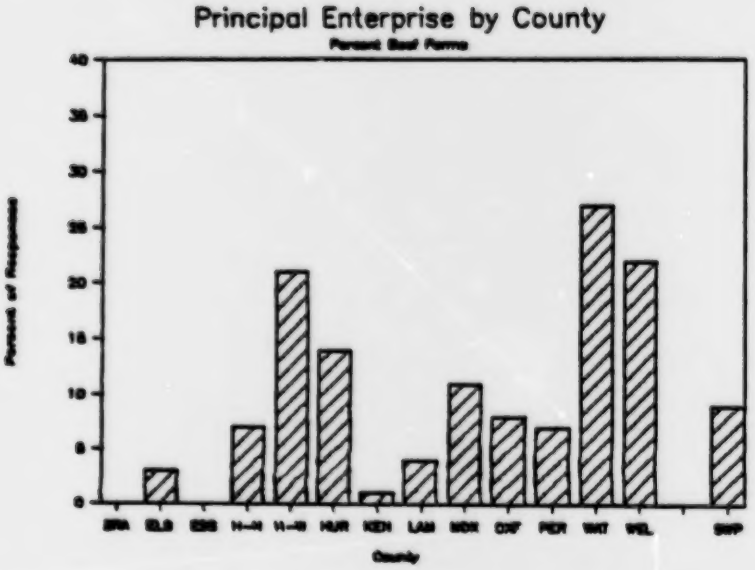


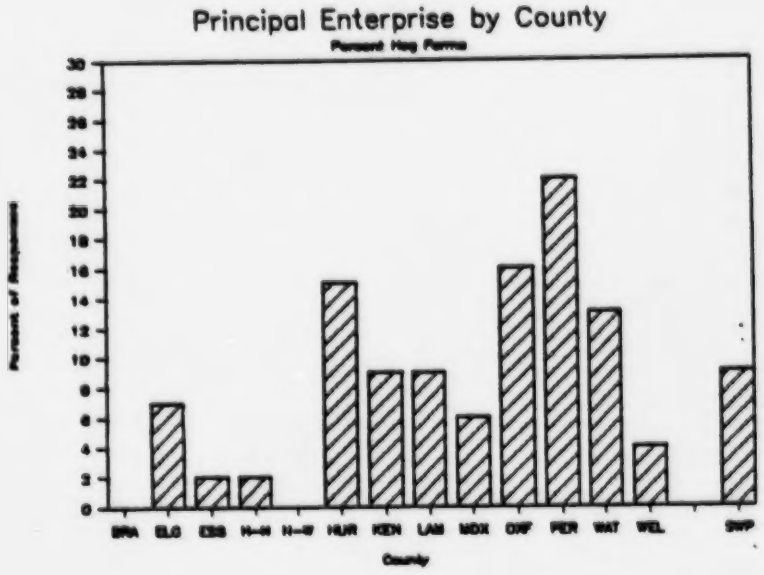
Figure 7



Beef farm operations by county illustrated in Figure 7, previous page, ranged from highs of 27% in Waterloo and 22% in Wellington to lows of 0, 1, and 3% in Brant and Essex, Kent and Elgin respectively.

The distribution of hog farms (Figure 8) in the study area ranged from highs of 22% in Perth and 16% in Oxford to lows of 0% in Brant and Hamilton-Wentworth and 2% in Haldimand-Norfolk and Essex.

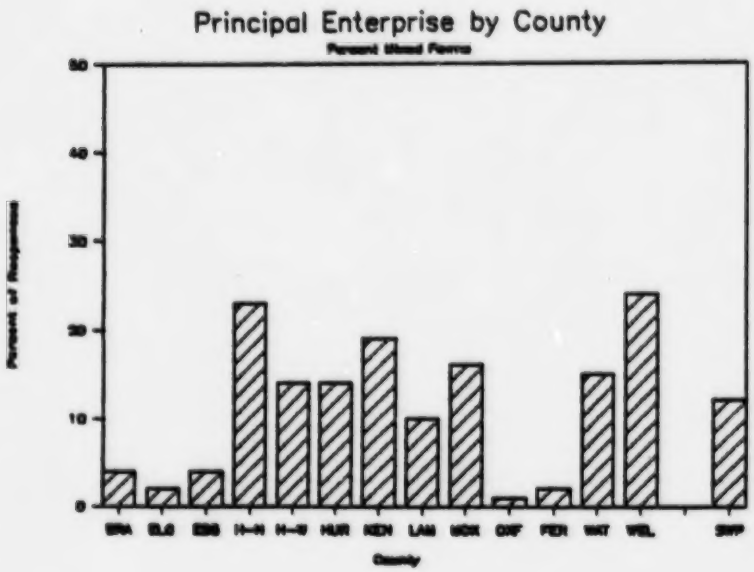
Figure 8



Mixed Farming

Figure 9 illustrates the distribution of mixed farming by county. The highest percentages of mixed farm operations per county were: 24% in Wellington, 23% in Haldimand-Norfolk, 19% in Kent, and 16% in Middlesex.

Figure 9



Poultry

Poultry operations, while not numerous (6% in Lambton, and 3% in Elgin), did occur throughout the study area. Table 2 shown previously, illustrates the magnitude of some poultry operations.

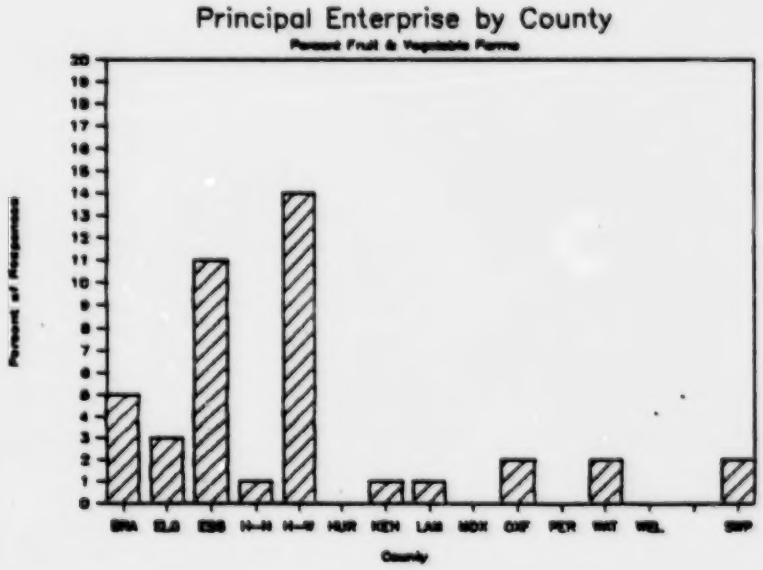
Tobacco Farming

Four percent of the respondents were tobacco farmers. They were concentrated in basically four counties: Haldimand-Norfolk (21%), Elgin (18%), Brant (9%), and Oxford (17%). As shown in Table 2 tobacco farms in the rest of the study area were a small percentage of the farms on which interviews were conducted.

Fruit and Vegetables

Fruit and vegetable operations (Figure 10) were greatest in Hamilton-Wentworth (14%), Essex (11%), and Brant (5%), while other counties had little in the way of fruit and vegetable operations.

Figure 10



5.1.2 Livestock In The Study Area

In an attempt to understand the nature of the farm enterprise and to establish a general notion of the amount of manure a particular operator was dealing with, questions were asked regarding the annual numbers of cattle, hogs, sheep and poultry produced by the farm. Farm operators were asked to estimate their annual production of livestock and select the category closest to their production. Figures 11 through 14 illustrate the size of livestock operations broken down by size categories. The information in the figures gives an impression of the intensity of livestock operations. This information can be used to estimate nitrogen and phosphorus loadings from manure on an animal-unit basis.

Figure 11

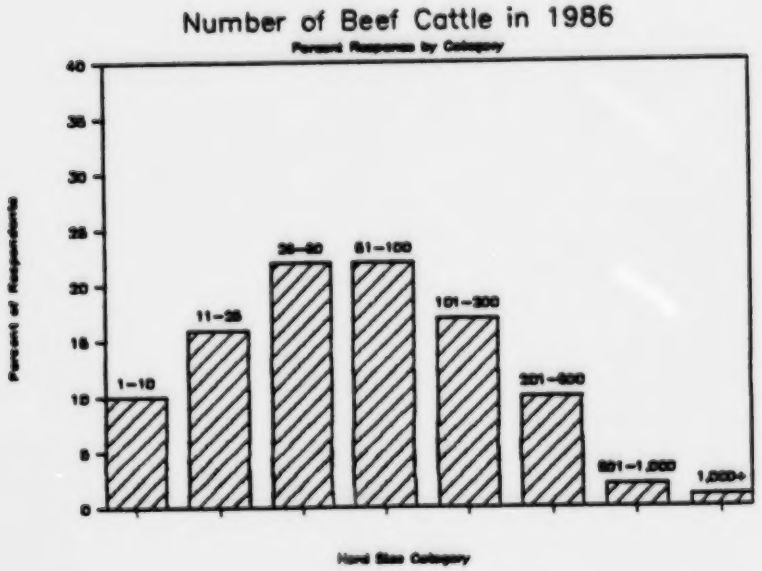


Figure 12

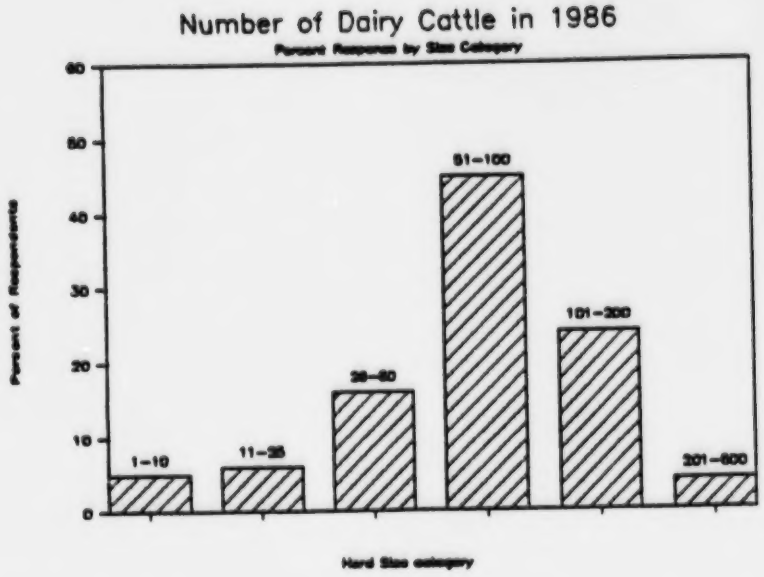


Figure 13

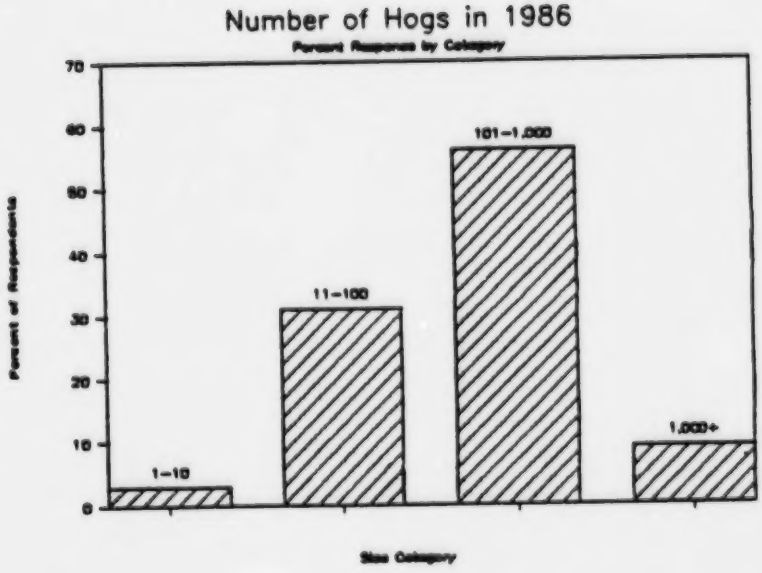
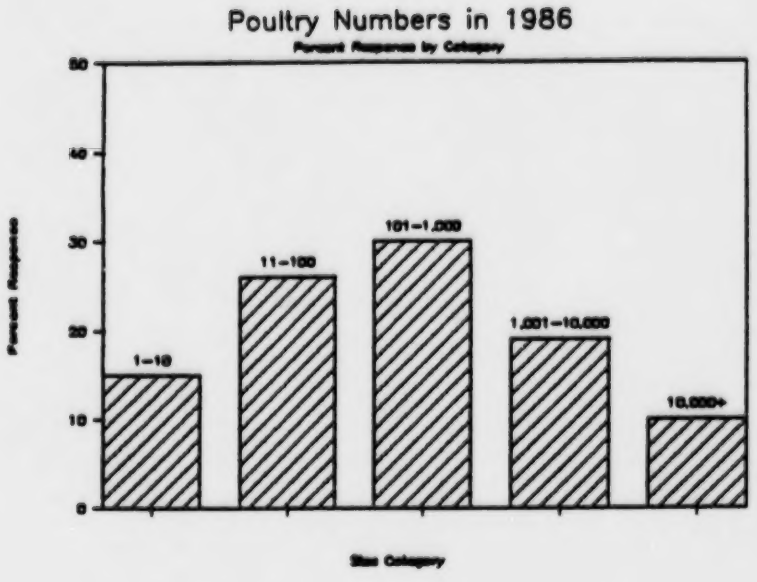


Figure 14



5.1.3 Size of Farm Operations

An examination of Table 3 shows that 40–99 hectare farms are the most common type and comprised 37% of the responses in the study area, followed by farms of 100–199 hectares (26%), and farms of 20–39 hectares (15%). Farms of smaller size constituted only 1% of the sample while larger farms more than 400 hectares made 5% of the sample.

Table 3

County/Region	Size of Operation Hectares 1-4 %	5-19 %	20-39 %	40-99 %	100-199 %	200-399 %	400-800 %	800+ %
Brant	0	4	9	39	9	17	0	22
Elgin	0	3	5	33	36	13	8	2
Essex	0	20	16	30	23	8	3	0
Haldimand-Norfolk	2	9	20	30	16	13	0	10
Hamilton-Wentworth	0	7	15	36	22	13	0	7
Huron	1	1	14	42	32	7	2	1
Kent	0	3	15	33	28	20	0	1
Lambton	0	6	15	39	26	9	5	0
Middlesex	0	2	16	30	34	14	3	1
Oxford	0	4	8	48	22	12	0	6
Perth	0	0	14	49	21	14	0	2
Waterloo	0	8	31	26	23	10	0	2
Wellington	0	6	22	38	27	6	0	1
SWEEP Study Area	1	5	15	37	26	11	4	1

5.1.4 Age of Operator

Table 4, "Age of Operator", demonstrates that the most predominant age category in the SWEEP study area was 45-54 (29%), followed by 35-44 (24%), and 55-64 (21%). Farmers both younger and older than this constituted less than 30% of the study area population.

Table 4

County/Region	Age of Operator Percent Response by Age Class 15-19 %	20-24 %	25-34 %	35-44 %	45-54 %	55-64 %	65-69 %	70 + %
Brant	0	0	4	13	33	33	9	4
Elgin	0	2	10	16	31	30	10	1
Essex	0	0	9	28	26	20	9	8
Haldimand-Norfolk	0	0	14	18	27	31	7	3
Hamilton-Wentworth	0	14	14	0	29	36	7	0
Huron	0	1	20	23	26	20	5	3
Kent	1	1	12	27	33	15	7	2
Lambton	0	1	15	26	24	20	9	5
Middlesex	0	2	15	26	26	17	9	5
Oxford	1	0	11	31	31	18	5	3
Perth	0	1	19	23	31	21	4	1
Waterloo	0	4	20	20	29	25	0	2
Wellington	0	3	18	18	33	21	4	3
Sweep Study Area	<1	1	15	24	29	21	7	3

Table 5 shows the number of years that the farmer had been working the parcel of land involved in the survey. The table indicates a high proportion in the 6-10, 11-20, and 21-30 year groups. A high proportion of the 11-20 year category, the most prevalent group, occurred in Oxford (34%), Lambton (32%), and Perth (31%). It is interesting to note high occurrences of the 2-5 year category in Brant, Elgin, Wellington and Perth.

Table 5

Years Site Farmed by Operator
Percent Response by Category

County	0-1 %	2-5 %	6-10 %	11-20 %	21-30 %	31-40 %	41-50 %	50+ %
Brant	0	23	18	27	14	21	5	0
Elgin	8	19	10	21	13	21	7	0
Essex	0	8	10	25	24	12	9	7
Haldimand-Norfolk	9	9	14	23	15	14	4	0
Hamilton-Wentworth	0	21	22	29	0	10	4	2
Huron	5	14	20	28	13	13	5	1
Kent	1	17	15	26	19	11	5	0
Lambton	1	14	16	32	15	18	8	5
Middlesex	4	11	28	24	15	12	9	1
Oxford	4	10	16	34	22	19	9	5
Perth	2	20	15	31	13	12	6	5
Waterloo Region	4	10	15	29	26	10	5	3
Wellington	4	21	11	25	15	13	5	4
Sweep Study Area	4	14	16	28	17	13	6	2

5.1.5 Information Sources

A number of questions were asked regarding sources of information concerning soil erosion or conservation. Farmers were asked whether they had received any information in the previous year from meetings, OMAF News, other farm publications, radio or television, books or journals, and research institutes or universities.

Farm publications were the most commonly used (81%), followed by radio or television (65%). OMAF News was a source for 61% of respondents while meetings (41%), books and journals (34%) and research institutes and universities (22%) were also used by farm operators.

5.1.6 Representativeness of Results

The results obtained from the survey can be assessed to determine whether the characteristics of farm operations are similar to the true distribution in the SWEEP study area. Where the distributions are similar, the survey results may be taken as representative of the whole study. Assessments were carried out on a number of variables.

Acreages of crops were compared to total acreages for the crops found in Publication 20, Agricultural Statistics for Ontario, 1985. The occurrence of each crop from the two sources was ranked in decreasing order of magnitude. This revealed a ranked similarity of occurrence for crop acreage at the county and study area levels. For all crop acreages, except fruit and vegetables which was not assessed, the same four counties were comparably ranked in the survey and in the county.

In 1984, a survey of 1,026 farmers in Southwestern Ontario gathered data on crop acreages. Figures 15 to 18 following provide a visual comparison of crop areas obtained in this survey and those obtained in the O.I.P. study (Wall, Vaughan and Driver, 1985).

Figure 15

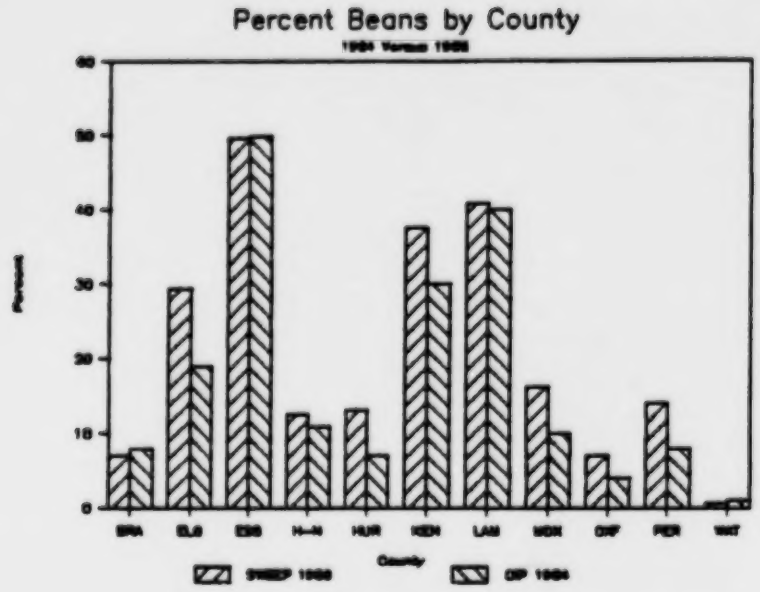


Figure 16

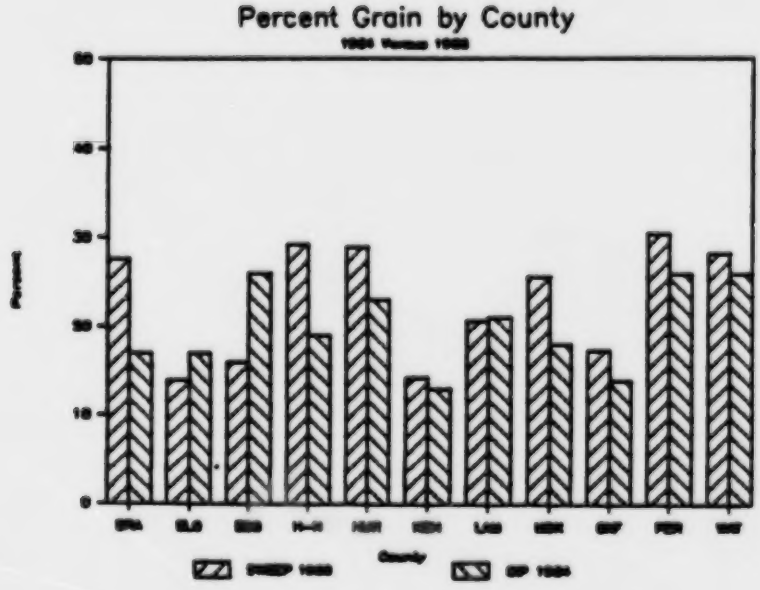


Figure 17

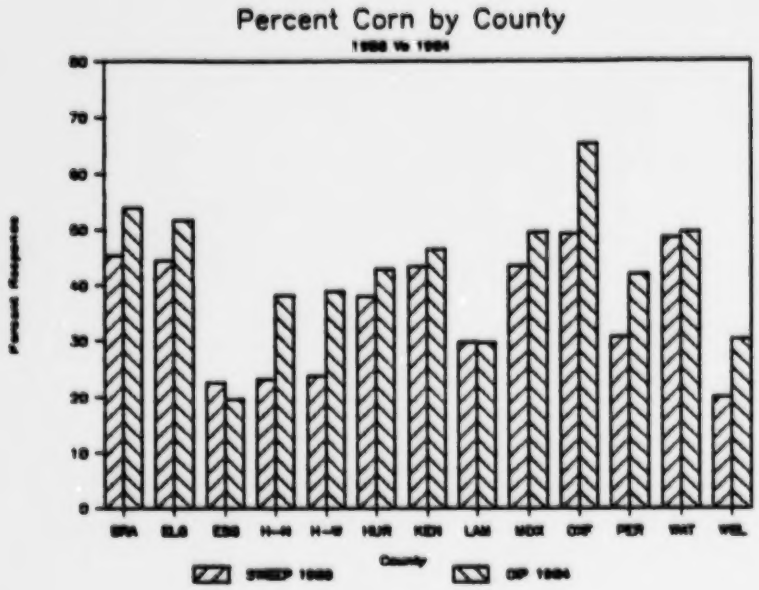
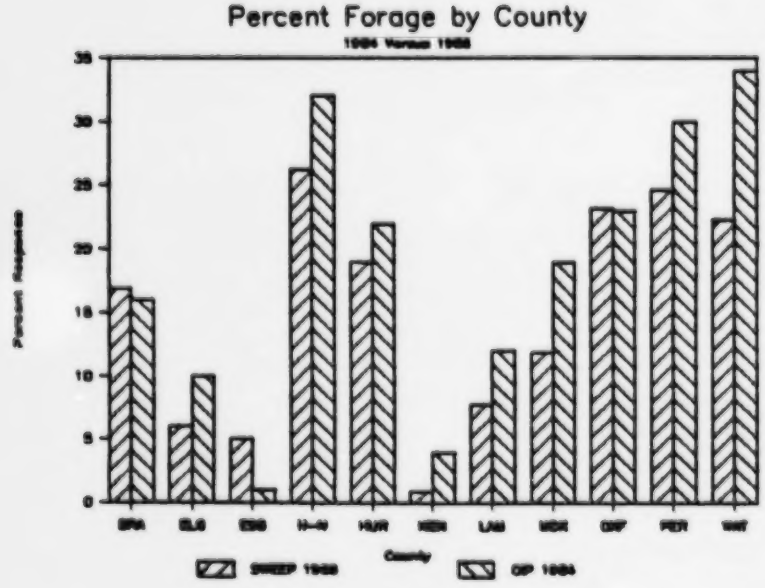


Figure 18



5.2 CROPPING PRACTICES

5.2.1. Crops Grown

The type of crop grown and how it is managed has a strong influence on productivity and erosion potential of the land. Fallow land is known to have the highest erosion potential, whereas a forage will provide good vegetative cover that will protect the soil, promote good soil structure and dissipate the erosive energy of wind and water.

To determine the percent of cropland acreage in the study area (Table 6) farmers were asked what crops were harvested from each of their fields in 1986. The eleven crop choices were: 1) grain corn; 2) silage corn; 3) soybeans, 20-30" rows; 4) soybeans 7" rows; 5) white beans; 6) fall grain or oilseed; 7) spring grain or oilseed; 8) forage; 9) tobacco; 10) vegetables and market gardening; and 11) fruit.

For ease of analysis, the acreages of grain and silage corn were combined, as were all types of beans, and fruit, vegetable and market gardening. This yielded seven rather than eleven categories of crops grown. Table 6 provides the recorded crop acreages and the resultant percentage of each crop grown in the 13 counties.

Corn was the crop grown most extensively in all the counties (36%), followed by beans (20%), forages (17%), fall cereals (12%), spring cereals (11%), fruits and vegetables (2%), and tobacco (slightly greater than 1%).

Corn acreage was highest (49%) in the R.M. of Waterloo and Oxford County, Brant County (45%) and Elgin and Middlesex at 44 percent. Lower values were found in Haldimand-Norfolk and Essex (23%). Wellington had the lowest value at 20%.

Although 20% of the total crop acreage in the study area was in beans, the county distribution varied considerably. Values ranged from a low in Wellington and Waterloo of 1%, to a high of 50% in Essex.

Forage acreages had a varied county distribution, ranging from a high of 48% in Wellington to a low of 1% in Kent. The remaining crops of fall and spring cereals (23%), fruits and vegetables (2%), and tobacco (1%) contributed to 26% of the total study area crop acreage. On a county basis, Haldimand-Norfolk had the highest percent acreage of fall cereals (22%) while the Regional Municipality of Waterloo had the lowest (5%). For spring cereals, Wellington and Waterloo each had the highest percent acreage (23%) while low values were found in Elgin, Kent and Essex, (each 1%). For fruit and vegetables, Hamilton-Wentworth had a high percent figure (16%) while the remaining low values were evenly distributed among the other counties. For tobacco, as expected, the majority of acreage was distributed between Haldimand-Norfolk and Elgin.

Table 6

Cropland in the Study Area

County/Region	Corn ha	Corn %	Beans ha	Beans %	Spring Cereals ha	Spring Cereals %	Fall Cereals ha	Fall Cereals %	Forage ha	Forage %	Tobacco ha	Tobacco %	Fruit & Vegetables ha	Fruit & Vegetables %	Total ha	Total %
Brant	308	45	48	7	47	7	141	21	115	17	14	2	7	1	679	100
Elgin	987	44	652	29	28	1	285	13	134	6	114	5	20	1	2,218	100
Essex	584	23	1,284	50	20	1	394	15	131	5	0	0	170	7	2,582	100
Haldimand-Norfolk	558	23	303	13	175	7	528	22	631	26	153	6	56	2	2,405	100
Hamilton-Wentworth	81	24	0	0	45	13	23	7	139	40	0	0	54	16	343	100
Huron	1,845	38	635	13	985	20	418	9	923	19	0	0	40	1	4,846	100
Kent	1,269	43	1,101	38	33	1	386	13	27	1	2	0	108	4	2,926	100
Lambton	909	29	1,245	40	111	4	518	17	236	8	0	0	66	2	3,086	100
Middlesex	1,892	44	703	16	442	10	673	15	518	12	56	1	61	1	4,344	100
Oxford	1,576	49	223	7	333	10	221	7	742	23	76	2	26	1	3,198	100
Perth	1,170	31	535	14	813	21	346	9	941	25	0	0	0	0	3,805	100
R.M. of Waterloo	667	49	10	1	313	23	75	5	307	22	0	0	0	0	1,372	100
Wellington	461	20	31	1	529	23	159	7	1,104	48	0	0	21	1	2,306	100
SHEEP Study Area	12,309	36	6,770	20	3,873	11	4,166	12	5,947	17	415	1	629	2	34,109	100

5.2.2 Crop Rotation

A crop rotation of cereals and forages is often essential for maintaining good soil structure and yields. A rotation that includes forages is an effective means of controlling erosion and reducing phosphorus loss. Agricultural fields left bare in the winter months are subject to runoff events. Winter cereals and forage crops assist in erosion control by providing vegetative cover during winter and spring runoff. Other benefits of good crop rotations are a reduction in insect buildup and disease problems associated with continuous cropping. However, if markets do not exist for alternate crops of forage or cereal then they may not be practical for all farmers.

The six types of rotations recorded in the survey were: 1) row crops, 2) row crops and cereals, 3) row crops, cereals and forage, 4) row crops and forage, 5) cereals and forage, and 6) forage and pasture.

SWEEP study area results (Table 7) indicated that on 40% of fields surveyed there was a rotation of row crops, cereals and forage; 32% had row crops and cereals; 10% were just row crops; 8% had a rotation of cereal and forage, 5% were a rotation of forage and pasture, while only 1% had no rotation at all.

The 40% of those fields in the study area where a rotation of row crops, cereal and forage was practiced suggests an awareness of the need for a rotation which includes a forage crop. Over 50% of the responses in the counties of Perth (55%), Huron and Waterloo (52%) each, and Wellington (50%) indicate that forages were included in the rotation.

The results showed that few of the fields in Wellington and Waterloo, (8% and 10% respectively) had a rotation of row crops and cereals. Instead, a rotation of row crops, cereal and forage was the principal rotation. Eight percent of the fields in the study area had a rotation of cereal and forage.

Responses indicated the highest incidence of the rotation of row crops and forage were in the R.M. of Waterloo (16%), followed by Oxford at 11%. Responses to continuous row cropping (rotation of row crops only) were relatively low in the study area (10%). The counties of Kent (28%), Elgin (27%), and Essex (26%) were considerably higher than the overall area. In the remaining counties, responses indicated continuous row cropping occurred less than 13% of the time.

Table 7

Crop Rotations
Percent by Category

County/Region	Row Crops %	Row Crops & Cereals %	Row Crops Cereals & Forage %	Row Crops & Forage %	Cereals & Forage %	Forage & Pasture %	Rotation Not Used %
Brant	12	35	43	6	2	2	0
Elgin	27	44	24	1	2	2	0
Essex	26	51	20	0	1	2	0
Haldimand - Norfolk	9	40	28	2	17	4	0
Hamilton - Wentworth	3	28	48	8	3	10	0
Huron	5	30	52	0	7	6	0
Kent	28	50	19	1	0	2	0
Lambton	9	55	30	1	1	3	1
Middlesex	14	38	34	6	2	6	0
Oxford	9	20	44	11	6	10	0
Perth	3	22	55	3	16	1	0
Waterloo	4	10	52	16	13	5	0
Wellington	0	8	50	4	25	13	0
SHEEP Study Area	10	32	40	4	8	5	1

5.3 EROSION CONTROL PRACTICES

5.3.1 Strip Cropping

Strip cropping is used to control erosion on long, smooth slopes. When compared to cropping up and down the slope, strip cropping across the slope has been reported to reduce soil losses by as much as 60% (Wall, Vaughan and Driver, 1985). True strip cropping occurs where a strip of forage alternates with a strip of row crop or cereals.

According to survey results (Table 8) only 3% responded positively to this practice.

Table 8

Erosion Control Practices
Percent Response

County/Region	Strip Cropping Yes %	Strip Cropping No %	Field Border Yes %	Field Border No %	Ploudown Yes %	Ploudown No %
Brant	0	100	0	100	21	79
Elgin	1	99	1	99	8	92
Essex	3	97	1	99	19	81
Haldimand-Norfolk	0	100	1	99	16	84
Hamilton-Wentworth	0	100	0	100	16	84
Huron	12	88	1	99	21	79
Kent	1	99	1	99	20	80
Lambton	0	100	2	98	12	88
Middlesex	1	99	1	99	11	89
Oxford	2	98	5	95	7	93
Perth	2	98	5	95	40	60
Waterloo	1	99	1	99	14	86
Wellington	1	99	0	100	3	97
Sweep Study Area	3	97	2	98	16	84

The highest proportion of strip cropped fields were found in Huron (12%) and Essex (3%). The percentage of this practice in the remaining counties, with the exception of Perth and Oxford (2% each), was negligible.

5.3.2 Plowdown

The use of clover as a plowdown crop is beneficial to soil conservation. It increases organic matter, improves soil structure and increases the water holding capacity of the soil.

According to survey results (Table 8), only 16% had a plowdown crop. The counties in which this occurred most often were Perth (40%), Huron and Brant (21%), and Kent (20%). The percentage of plowdown responses was low in Elgin (8%), Oxford (7%), and Wellington (3%).

5.3.3 Field Borders

These occur when a border of cereals or forage is planted around a row crop such as corn or beans. These areas can facilitate access for harvesting a row crop when the border is cut first. More importantly, they serve as a trap for the movement of sediment and fertilizers transported by water from the field.

According to survey results (Table 8) only 2% responded positively to this practice. The counties in which this occurred most often were Perth and Oxford at 5%.

5.3.4 Field Border Widths

The effectiveness of a field border depends on its width and type and condition of its vegetation. The reported widths of field borders may be seen in Table 9.

Table 9

County/Region	Field Border Width in Metres Percent by Category					
	<3m %	3-6m %	6-9m %	9-12m %	12-15m %	15+ %
Brant	0	100	0	0	0	0
Elgin	0	0	0	0	0	0
Essex	0	0	0	0	0	0
Haldiesand-Norfolk	0	100	0	0	0	0
Hamilton-Wentworth	0	0	0	0	0	0
Huron	0	0	0	100	0	0
Kent	0	0	0	100	0	0
Lambton	43	0	0	0	0	100
Middlesex	46	0	100	0	0	0
Oxford	17	44	39	0	0	0
Perth	0	0	0	100	0	0
Waterloo	0	0	0	0	0	0
Wellington	0	0	0	0	0	0
Sweep Study Area	8	37	29	24	0	3

In the SWEEP study area the most prevalent border widths were less than 3m (57%), 3 - 6m (22%), and 6 - 9m (15%). Table 8, shows that only 2% of the responses indicated that they had a field border. With this response rate it is difficult to generalize beyond the sample.

5.3.5 Land Management Practices

The questionnaire included a number of questions relating to additional land management practices which may occur on the farm. Erosion control structures, stream-bank stabilization, permanently vegetated buffer strips, tree windbreaks and reforestation were the measures investigated. Erosion control structures included a variety of structures designed to control the effects of moving water such as drop inlets, grassed waterways, terraces, rock chutes and protected tile drain outlets. Stream-bank stabilization measures included various forms of armouring such as gabion baskets or rip-rap. Improved cattle access controls included items such as provision of alternate water supplies for cattle, or fencing of streams and municipal drains. Other measures included tree windbreaks and reforestation.

In the Sweep study area, 15% of the responses indicated use of an erosion control structure on the farm. Erosion control structures are most common in Elgin (29%), Middlesex (24%) and Oxford (26%).

Stream-bank stabilization measures were used by 14% of the respondents in the SWEEP study area. Middlesex (26%) and Oxford (25%) reported these measures most often.

The use of permanently vegetated buffer strips was the most commonly reported (23%) land management practice in the study area. Elgin and Oxford both reported 38% use of buffer strips and Middlesex reported 40% use, whereas Essex reported only 5% use of permanently vegetated buffer strips.

Tree windbreaks were the second most commonly reported land management practice. Oxford and Wellington counties reported the highest rates, followed immediately by Kent, Essex and Lambton counties. In the latter three counties windbreaks are particularly important because of the large field sizes and the relative lack of remaining natural woodlots. As expected, reforestation was the least common of the reported practices. Only 8% of the responses overall in the SWEEP study area indicated that they had reforested land within the last five years.

Middlesex and Elgin (16%) and Oxford (15%) has the highest reported rates of reforestation, while the lowest rates occurred in Kent, Essex and Lambton.

5.4 CROPPING CHANGES

5.4.1 Why Crops Were Changed

Changes in cropping and land management practices can have a significant bearing on soil conservation and erosion control. Survey results indicated that 21% of fields surveyed exhibited a cropping change within the last five years. The remaining 79%, who either did not change their practices or did not give a reason for changing. The main reasons for cropping changes (Table 10) were: Economic Reasons (15%), Reduction of Erosion and Better Crop Rotation, (14%) each, and Changed Crops, Enterprise or Land Base (12%). The remaining reasons for change were all below the 12% level. It is encouraging to note that, in comparison to the '84 study, more respondents changed for other than just economic reasons. Changes to "Reduce Erosion" occurred in approximately 22% of Elgin fields surveyed, 21% of fields in Waterloo and 20% of Oxford fields. Values in the remaining counties ranged between 11-19%.

In Brant County 33% of respondents indicated that crops were changed because of poor soil structure. Other counties placing emphasis on soil structure were Kent and Perth at 15% each. The remaining counties had changes in the 6-11% range.

Crops were changed in order to improve yields in Brant and Waterloo (17%), Perth (16%), and Kent (15%). Values in the remaining counties fell below the 15% figure.

Responses indicating that crop changes to achieve "More Plowdown" were highest in Perth (19%).

Responses under the category "Changed Crop Type, Enterprise or Land Base" were very high in Essex (67%) and significant in Huron (26%), Wellington (21%), Middlesex (18%) and Haldimand-Norfolk (16%).

Responses indicated that cropping changes to "Reduce Tillage" were highest in Oxford (19%), Lambton (17%), and Kent and Waterloo (15%). The remaining county values were lower than 10%.

A high number of responses indicated changes in crops for "Economic Reasons" were found in Elgin (39%), Haldimand-Norfolk and Huron (26%), Middlesex (25%), and Essex (22%).

Many of those changing to "Better Crop Rotations" were found in Brant (33%), Oxford (22%), and Wellington (21%). Many of the remaining county values fell below or close to the 14% level.

A high number of responses indicating changes because of "Changed Fertilizer, Herbicide or Pesticide Use" were found in Hamilton-Wentworth (12%), Huron (13%) and Wellington (11%). Many of the remaining county values fell close to the 6% level.

Table 10

Reasons for Cropping Change
Percent Response by Category

County/Region	Reduce Erosion %	Poor Soil Structure %	Improve Yields %	More Plowdown %	Changed Crops %	Reduced Tillage %	Economic Reasons %	Better Crop Rotation %	Changed Fert. Herb. Or Pesticide %
Brant	0	33	17	0	0	0	17	33	0
Elgin	22	10	0	0	0	4	39	17	0
Essex	0	0	0	0	67	0	22	11	0
Haldimand-Norfolk	9	11	2	9	16	7	26	16	4
Hamilton-Wentworth	17	10	12	17	6	0	0	10	12
Huron	13	9	4	0	26	5	26	4	13
Kent	10	15	15	0	5	15	15	0	9
Lambton	10	10	11	13	10	17	0	15	6
Middlesex	14	3	13	5	10	3	25	0	6
Oxford	20	7	0	6	14	19	9	22	5
Perth	0	15	16	19	0	6	11	13	4
Waterloo	21	6	17	6	9	15	6	17	3
Wellington	11	0	7	7	21	4	10	21	11
Sweep Study Area	14	11	11	9	12	8	15	14	6

5.5 TILLAGE

5.5.1 Tillage Practices

Tillage machines, time of tillage, tillage depth, and tillage direction are extremely important to soil conservation. Soil conservation tillage machines can be used to leave the soil roughened and with a residue cover of usually greater than 30%. To mitigate soil losses, it is better to till in the spring.

In terms of conserving soil, the depth of tillage is as important as the time of tillage. The shallower tillage depths allow for more surface cover (residue). Tilling at excessive depths can result in excessive mixing of the soil and subsoil.

On sloping fields, the direction of tillage is just as important to conserving soil as types of tillage machines, tillage depth and time of tillage. Ploughing across the slope and on the contour are conservation practices which help to hold soil in place.

Results showed approximately 20% of farmers have changed tillage practices in the last 5 years. Based on those who have changed, 30% gave the primary reason for change as a desire to reduce erosion. Additional reasons were changing crops, equipment or land base (19%) and to reduce costs (16%).

5.5.2 After Harvest Tillage Machines

Table 11 shows responses to the first two types of tillage machines or combination of machines used over the fields after harvesting the 1985 crop.

On SWEEP study area fields the moldboard plough was still the most commonly used tillage practice (74%). The remaining 26% comprises all other types of tillage machines. Huron (92%) and Wellington (89%) had the highest percent use of the moldboard plough in the 13 counties. The lowest amount of use was in Haldimand-Norfolk (39%).

It is encouraging to note the high level of use of the modified moldboard plough in Brant County (21%). It is encouraging to note a higher than average use of the disc/coulter chisel plough in Elgin (31%), Brant (19%) and Haldimand-Norfolk (14%). The chisel plough is considered effective on erodible, sloping soils and leaves approximately 50-70% of the residue on the surface. Response rates for all counties showed relatively low use. However, Essex at 13% and Lambton County, at 10%, were well above the study area value of 4%. Tandem-disc and harrows were used on 40% of the fields of Haldimand-Norfolk and 14% in Elgin.

The field cultivator's use was highest in Waterloo (11%), and Lambton and Perth (9% each). The response rate for the SWEEP study area was 4%.

Table 11

Primary Tillage Machines

County/Region	Moldboard Plough %	Modified Moldboard %	Disc/ coulter Chisel Plough %	Chisel Plough %	Tandem Disc & Harrows %	Cultivator %	Other %
Brant	60	21	19	0	0	0	0
Elgin	49	2	31	2	14	2	0
Essex	75	1	2	13	7	2	0
Haldimand-Norfolk	39	1	14	1	40	3	2
Hamilton-Wentworth	83	0	0	5	10	2	0
Huron	92	4	1	2	0	1	0
Kent	78	3	6	8	2	1	2
Lambton	65	5	2	10	5	9	4
Middlesex	76	1	7	2	7	4	3
Oxford	82	1	4	3	0	1	9
Perth	79	2	4	4	1	9	1
Waterloo	79	1	1	2	6	11	0
Wellington	89	0	5	1	0	4	1
Sweep Study Area	74	2	6	4	7	4	3

5.5.3 Timing of After Harvest Tillage

Table 12, "Timing of Primary Tillage", shows that most ploughing occurred in the fall from October to December (73%) while the least amount (10%) occurred in summer between June and September. The highest occurrence of fall ploughing was in Huron County (89%). It was lowest in Oxford and Elgin at 54% each. The study area figure for ploughing in Spring between March and May was 17%. Farm fields spring ploughed in Elgin (37%), Oxford (39%), and Hamilton-Wentworth (36%), were all well above this figure.

Table 12

Timing of Primary Tillage
Percent Response by Category

County/Region	Fall %	Spring %	Summer %
Brant	67	17	16
Elgin	54	37	9
Essex	70	15	15
Haldimand-Norfolk	55	11	34
Hamilton-Wentworth	59	36	5
Huron	89	6	5
Kent	80	16	4
Lambton	82	15	3
Middlesex	72	21	7
Oxford	54	39	7
Perth	80	7	13
Waterloo	83	12	5
Wellington	86	10	4
Sweep Study Area	73	17	10

Summer ploughing was highest in Haldimand-Norfolk (34%). This was probably due to a prevalence of a rotation of tobacco and fall cereals. Other high values were in Brant (16%), Essex (15%), and Perth (13%). The remaining values fell below 10%.

5.5.4 After Harvest Tillage Depth

Table 13, "Primary Tillage Depth" indicates that in the study area, most fields (61%) were primary tilled to a depth of 11-15 cm, while few (1%) were ploughed to depths greater than 26 cm.

It is surprising to note that a significant proportion of the fields in the study area were primary tilled at shallow depths.

Table 13

Primary Tillage Depth in Centimetres
Percent Response by Depth Class

County/Region	1-10 %	11-15 %	16-25 %	25+ %
Brant	17	74	9	0
Elgin	25	35	39	1
Essex	16	36	46	2
Haldimand-Norfolk	44	52	3	1
Hamilton-Wentworth	10	34	56	0
Huron	22	73	5	0
Kent	21	54	23	2
Lambton	17	58	24	1
Middlesex	16	64	19	1
Oxford	3	67	30	0
Perth	16	72	12	0
Waterloo	18	70	12	0
Wellington	2	71	27	0
SHEEP Study Area	18	61	20	1

5.5.5 Direction of Travel in Relation to Slope

Table 14, "Primary Tillage Direction" shows that the direction most frequently ploughed in the study area (63%) was "Not Related to Slope". This strongly suggests that slope was not a large consideration. Ploughing without consideration for slope occurred most widely on the fields of Elgin (96%), Lambton (87%), and Brant (77%). Essex, which has relatively flat land, had the lowest percent figure for this ploughing direction.

Contour ploughing offers extremely good protection against soil loss but occurred on only 5% of the study area fields. At the county level the highest number of fields being contour ploughed were in Haldimand-Norfolk (12%) and Huron (11%).

Table 14

Primary Tillage Direction
Percent Response by Category

County/Region	Up & Down The Slope %	Across Major Slope %	On The Contour %	Not Related To Slope %
Brant	7	16	0	77
Elgin	1	1	2	96
Essex	21	27	1	51
Haldimand-Norfolk	27	5	12	56
Hamilton-Wentworth	17	19	0	64
Huron	8	27	11	54
Lambton	6	7	0	87
Middlesex	26	20	0	54
Oxford	14	24	4	58
Perth	18	22	2	58
Waterloo	14	13	1	72
Wellington	12	18	1	69
Sweep Study Area	15	17	5	63

5.5.6 Seedbed Preparation

Results with respect to seedbed tillage are found in Tables 15, 16, 17 and 18. As with primary tillage, secondary tillage machine types, time of year, how often tilling is done and repeated, all have a direct effect on soil erosion.

5.5.7 Seedbed Tillage Machines

Table 15 shows results of responses to three possible machines used in combination or separately per field to prepare the seedbed for crops which were harvested in 1986.

The number of passes over a field may be more important than the type of tillage implement for controlling soil erosion. Of all secondary tillage machines listed in the questionnaire the mulch tiller used once over a field is considered the best conservation tillage practice under appropriate soil conditions. However, as with primary tillage equipment, all secondary tillage implements must be assessed for each situation.

In the study area the most prevalent type of seedbed implements were the cultivator (49%) and disc and harrows (30%). At the county level, cultivator use was highest in Huron (65%) and lowest in Haldimand-Norfolk (29%). The disc and harrows was most often used in Essex (48%) and least often used in Perth (12%).

Table 15

Seedbed Tillage Machines
Percent Response by County

County/Region	Cultivator %	Disc & Harrows %	Harrows %	Culti-packer /Roller %	Mulch Tiller %	Other %
Brant	49	41	4	0	6	0
Elgin	40	36	16	4	2	2
Essex	43	48	1	1	1	6
Haldimand-Norfolk	29	43	6	1	2	19
Hamilton-Wentworth	48	44	8	0	0	0
Huron	65	22	8	4	0	1
Kent	51	27	2	18	1	1
Lambton	54	31	7	5	1	2
Middlesex	53	31	6	3	2	5
Oxford	50	31	4	6	2	7
Perth	30	12	6	13	1	18
Waterloo	53	23	17	5	0	2
Wellington	45	32	9	8	0	6
Sweep Study Area	49	30	7	6	1	0

In Waterloo, harrows were most prevalent (17%). In the study area, cultipacker/roller was used in 6% of the time, however, it was used 18% of the time in Kent. The mulch tiller, an implement which leaves high amounts of crop residue, had a high level of use in Brant County (6%).

5.5.8 Seedbed Tillage, Times Tilled and Why Repeated

Study area results (Table 16) show that 46% of fields were tilled twice.

Table 16

Number of Times Seedbed Tilled
Percent Response by Category

County/Region	Once %	Twice %	Three times %	Four Times %	Five Or More %
Brant	19	70	9	2	0
Elgin	38	43	15	4	0
Essex	25	42	31	1	1
Haldimand-Norfolk	60	30	8	1	1
Hamilton-Wentworth	28	63	7	2	0
Huron	19	56	24	1	0
Kent	27	59	13	1	0
Lambton	27	52	19	2	0
Middlesex	38	46	15	1	0
Oxford	54	35	7	2	2
Perth	37	47	13	3	0
Waterloo	52	42	6	0	0
Wellington	47	45	8	0	0
Sweep Study Area	39	46	13	1	1

This was followed by 39% where only 1 pass was required. A high number of responses for twice tilled occurred in Brant (70%) and Hamilton-Wentworth (63%). The lowest figure for this category was in Haldimand-Norfolk at 30%. For once tilled, the highest number of responses occurred in Haldimand-Norfolk (60%) and Oxford (54%). The lowest occurrence was in Brant and Huron at 19%.

For three times tilled, Essex County had the highest number of responses (31%), while the lowest level was in Waterloo (6%).

Table 17 indicates the reasons seedbed tillage was repeated. A high proportion of the responses (94%) indicated that farmers re-tilled their fields because the seedbed was not fine enough. This was the case over 90% of the time for most counties. The exception was Haldimand-Norfolk where poor drainage (6%) and rain (12%) were the reasons for repetition.

Table 17

Reason for Repeating Seedbed Tillage
Percent Response by Category

County/Region	Water Ponding %	Poor Drainage %	Rain %	Surface Cracking %	Not Fine Enough %
Brant	0	0	0	0	100
Elgin	0	1	1	0	98
Essex	2	1	2	0	95
Haldimand-Norfolk	1	6	12	0	81
Hamilton-Wentworth	0	0	3	0	97
Huron	0	5	0	0	95
Kent	2	0	1	4	93
Lambton	2	1	1	0	96
Middlesex	1	0	1	3	95
Oxford	1	1	1	0	97
Perth	0	1	0	0	99
Waterloo	0	1	0	0	99
Wellington	0	3	0	0	97
Sweep Study Area	1	2	2	1	94

5.5.9 Timing of Seedbed Tillage

Study results showed (Table 18) that seedbed tillage occurred most often between March and May (85%), followed by October-December (8%) and June-September (7%). The highest level of October-December tillage was in Lambton (20%). A high level of the June-September tillage occurred in Haldimand-Norfolk (24%), Essex (18%), and Brant (14%).

Table 18

Timing of Seedbed Tillage
Percent Response By Category

County/Region	Oct-Dec %	Mar-May %	Jun-Sep %
Brant	9	77	14
Elgin	7	87	6
Essex	4	78	18
Haldimand-Norfolk	9	67	24
Hamilton-Wentworth	5	90	5
Huron	6	91	3
Kent	11	86	3
Lambton	20	77	3
Middlesex	12	82	6
Oxford	6	90	4
Perth	4	90	6
Waterloo	8	91	1
Wellington	4	93	3
SWEEP Study Area	8	85	7

5.6 PLANTING

5.6.1 Planters

In the SWEEP study area the most common type of planting equipment (Table 19) was the traditional row-crop planter (45%) and the seed drill (46%). Broadcasting seed was done 3% of the time. Transplanters were used in areas with specialized types of agriculture. Tobacco growing regions, such as Haldimand-Norfolk, reported the use of transplanters in 18% of the fields. In vegetable producing areas such as Essex, it was reported that transplanters were used in approximately 10% of the fields. In the SWEEP study area, transplanters were used 4% of the time.

Modified row-crop planters were used on 2% of the fields planted in Brant, Waterloo, and Kent to improve the seeding in heavy residue. Overall in the study area, modified row-crop planters accounted for approximately 1% of total use. Modified seed drills were used less than 1% of the time in the entire study area.

5.6.2 Planting Direction

Planting direction (Table 20) is an important consideration in determining whether rainfall, run-off and erosion will be reduced. As in tilling, most farmers tended to plant their fields without consideration for the effects of slope (61%). In Elgin, 95% of those responding indicated that they planted in a direction not related to the slope of the land. Over 70% of the responses in Lambton, Wellington, Elgin, Brant

Table 19

Planter Type
Percent Response by Category

County/Region	Regular Row Crop Planter %	Regular Seed Drill %	Modified Row Crop Planter %	Modified Seed Drill %	Broadcast %	Trans-Planter %
Brant	36	57	2	0	0	5
Elgin	53	32	1	0	2	12
Essex	41	42	0	0	7	10
Haldiand-Norfolk	26	47	1	0	8	18
Hamilton-Wentworth	51	25	0	0	11	13
Huron	52	47	0	0	0	1
Kent	67	21	2	1	4	5
Lambton	51	46	0	0	3	0
Middlesex	47	48	1	1	2	1
Oxford	46	42	1	1	8	2
Perth	44	55	0	1	0	0
Waterloo	42	53	2	0	3	0
Wellington	26	69	0	0	5	0
SWEEP Study Area	45	46	1	1	3	4

and Waterloo indicated planting was carried out irrespective of slope. Cross tabulations of planting directions by age category, showed that roughly the same proportion of farmers in all age groups tended to plant in similar fashions.

Table 20

Direction of Planting
Percent by Category

County/Region	Up & Down Major Slope %	Across Major Slope %	Round & round Field %	On the Contour %	Not Related To Slope %
Brant	16	11	0	0	73
Elgin	2	1	0	2	95
Essex	22	25	0	1	52
Haldimand-Norfolk	34	4	2	11	49
Hamilton-Wentworth	17	19	0	0	64
Huron	7	26	12	2	53
Kent	12	18	0	2	68
Lambton	5	7	0	3	85
Middlesex	27	20	1	2	50
Oxford	13	27	4	2	54
Perth	22	12	13	7	46
Waterloo	11	11	2	3	73
Wellington	8	11	10	1	70
Sweep Study Area	16	16	4	3	61

5.6.3 Drainage

Drainage tiles remove excess water and allow fields with excess moisture to dry out earlier. The operator can gain earlier access to the land to begin field operations.

Tiles may be installed in a systematic fashion covering a field or portion of a field. Tiles installed in low areas to improve drainage are termed random drainage. Where drainage tiles are not installed, the drainage is natural. Questions regarding each type of drainage were

asked for each field on the farm. Respondents replied with the area in each type of drainage. The areas have been regrouped into four classes: 1-4 ha, 5-10 ha, 11-20 ha, and 21-40 ha.

Responses regarding systematic drainage are shown in Table 21. The majority of systematic tile drainage (86%) was 20 hectares or less in extent. Fourteen percent of the systematic tile installations were in the 21-40 hectare range. Elgin, Essex and Kent had the highest response rate (25%, 29% and 22% respectively) in the 21-40 hectare range for systematic tile installations. Waterloo, Haldimand-Norfolk and Oxford had a high response rate (52%, 49%, and 48% respectively) regarding systematic tile installations in the 1-4 hectare range.

Table 21

Area of Systematic Drainage
Percent Response by Category

County/Region	1-4 ha	5-10 ha	11-20 ha	21-40 ha
Brant	20	60	10	10
Elgin	17	32	26	25
Essex	23	26	22	29
Haldimand-Norfolk	49	25	16	10
Hamilton-Wentworth	46	39	15	0
Huron	22	38	30	10
Kent	17	23	38	22
Lambton	35	23	27	15
Middlesex	25	38	24	13
Oxford	48	32	10	10
Perth	25	44	24	7
Waterloo	52	37	9	2
Wellington	36	41	20	3
SWEEP Study Area	29	33	24	14

Table 22 illustrates the percent of response by area of random tile drainage. Much lower response rates (8%) were observed for large random tile installations (those between 21 to 40 hectares). Throughout the SWEEP study area randomly installed tiles were most common (42% of

response) in installations of 1-4 ha. The frequency of response declined for each successive increase in installation size. Random placement of drainage was much more likely in installations of a small size than in large scale installations.

Table 22

Area of Random Drainage
Percent Response by Category

County/Region	1-4 ha %	5-10 ha %	11-20 ha %	21-40 ha %
Brant	29	57	14	0
Elgin	35	28	22	15
Essex	0	67	17	16
Haldimand-Norfolk	49	25	16	10
Hamilton-Wentworth	50	17	25	8
Huron	24	41	25	10
Kent	33	25	33	9
Lambton	45	26	17	12
Middlesex	36	34	23	7
Oxford	63	23	7	7
Perth	51	37	9	3
Waterloo	40	48	11	1
Wellington	62	22	10	6
Sweep Study Area	42	33	17	8

The same sort of overall relationship holds with natural drainage, shown in Table 23. The frequency of response was much higher for small areas of natural drainage (48% in the 1-4 ha category), while the frequency of response in the largest category (6% in 21-40 ha category) was low.

Table 23

Area of Natural Drainage
Percent Response by Category

County/Region	1-4 ha %	5-10 ha %	11-20 ha %	21-40 ha %
Brant	20	38	27	15
Elgin	22	56	11	11
Kent	33	52	10	5
Huron	37	38	19	6
Haldimand-Norfolk	44	35	11	10
Waterloo	45	35	15	5
Middlesex	47	36	13	4
Wellington	52	34	11	3
Lambton	53	29	12	6
Oxford	54	30	13	3
Essex	60	18	14	8
Perth	63	26	9	2
Hamilton-Wentworth	63	30	7	0
Sweep Study Area	48	33	13	6

5.7 FERTILITY

5.7.1 Manure Management

The use of manure as a fertilizer, method of application, timing of application and the timeliness of its incorporation into the soil are all pertinent factors in understanding the potential effects upon water quality. The Agricultural Code of Practice outlines a number of practices which can aid in maintaining adequate water quality. These quidelines deal particularly with the need to incorporate manure within 24 hours where possible, and to exercise caution when spreading manure on frozen ground.

In the SWEEP study area, less than 40% of the responses indicated that manure was applied (Table 24). Of those farms on which manure was spread, 83% of the fields were spread using a tractor and spreader. Solid manure applications dominate the other forms. Only 14% of the fields were spread using a tank. In 3% of the responses, irrigation was used to apply the manure.

Substantial variations occurred from county to county in the method of application. In Kent County, most fields were spread using a tractor and tank (54%), whereas in Wellington, Waterloo, Perth,

Middlesex and Haldimand-Norfolk, high proportions of the responses indicated the use of a tractor and spreader.

Table 24

Method of Applying Manure
Percent Response by Category

County/Region	Apply Manure Yes %	Apply Manure No %	Spreader & Tractor %	Spread With Tank %	Injected Into Soil %	Irrigate %	Other %
Brant	30	70	69	6	6	13	6
Elgin	19	81	78	23	0	0	0
Essex	15	85	63	34	0	3	0
Haldimand-Norfolk	27	73	97	2	0	1	0
Hamilton-Wentworth	37	63	100	0	0	0	0
Huron	48	52	75	23	0	0	0
Kent	27	73	41	54	0	6	0
Lambton	24	76	73	24	0	2	0
Middlesex	30	70	81	13	1	5	1
Oxford	54	46	74	23	0	3	0
Perth	41	59	85	13	0	2	0
Waterloo	73	27	84	12	0	5	0
Wellington	67	33	97	3	0	0	0
Sweep Study Area	39	61	83	14	0	3	0

Table 25 shows the timing of manure applications. During the fall, spring and summer 77% of the fields received applications of manure. Nine percent of the respondents indicated they spread manure during the winter, while 14% indicated manure was spread all year long.

Table 25

Timing of Manure Applications
Percent Response by Category

County/Region	Fall %	Spring %	Summer %	Winter %	Fall & Summer %	Fall Spring & Summer %	All Year %
Brant	25	0	6	0	44	25	0
Elgin	15	13	3	10	30	17	12
Essex	19	28	9	6	13	0	25
Haldimand-Norfolk	27	45	3	2	4	7	12
Hamilton-Wentworth	13	7	0	37	0	0	43
Huron	40	44	6	3	2	3	2
Kent	16	17	6	9	39	6	7
Lambton	28	16	12	30	4	0	10
Middlesex	20	20	8	7	21	10	14
Oxford	25	23	6	10	24	4	8
Perth	28	31	7	3	17	5	9
Waterloo	14	19	3	0	36	5	23
Wellington	19	15	3	4	37	10	12
Sweep Study Area	22	21	6	9	21	7	14

Timing of applications cross-tabulated with the type of farm operation revealed that dairy farmers accounted for the highest proportion of manure applications. In the case of year-round applications, dairy farmers accounted for 46% followed by mixed farming (22%) and beef operations (15%). Where winter applications occurred, 34% were made by dairy operations, 23% by hog operations and 20% by mixed farming operations.

It is interesting to review manure incorporation (Table 26) in light of the Agricultural Code of Practice. Throughout the study area, and approximately 30% of the time, manure was spread onto forage crops. In this case, there is no means of incorporating the manure. However, in cases where cultivation was possible, low rates of incorporation within

Table 26

Incorporation of Manure
Percent Response by Category

County/Region	Same Day %	1-3 Days %	3+ Days %	Spread On Forage %
Brant	0	50	43	7
Elgin	3	11	65	21
Essex	41	9	11	39
Haldimand-Norfolk	36	20	16	28
Hamilton-Wentworth	0	14	56	30
Huron	4	38	29	29
Kent	30	39	19	12
Lambton	10	20	47	23
Middlesex	14	9	50	27
Oxford	18	31	30	21
Perth	10	22	33	35
Waterloo	9	14	50	27
Wellington	14	22	14	50
Sweep Study Area	14	24	32	30

the recommended time span were apparent. In only 14% of the responses was manure incorporated within 24 hours. One third (32%) of the responses indicated that manure was not incorporated for more than three days.

5.7.2 Nitrogen Fertilizer

Applications of commercial nitrogen fertilizers, as with manure applications, were addressed for each field of the farm. Information regarding timing and method of application were elicited. Farmers provided information with respect to some 3,800 fields upon which nitrogen had been applied (Table 27). Of that total, 48% had nitrogen applied on the basis of the farmer's experience. Farmers indicated that 27% of fields had nitrogen applied on the basis of a soil test recommendation within the previous year. On 25% of the fields, nitrogen was not applied.

Table 27

Basis for Applying Nitrogen Fertilizer
Percent Response by Category

County	Experience %	Soil Test %	Not Applied %	Row Total %
Brant	81	15	4	100
Elgin	65	22	13	100
Essex	46	22	32	100
Haldimand - Norfolk	46	26	28	100
Hamilton - Wentworth	52	9	39	100
Huron	32	46	22	100
Kent	41	33	26	100
Lambton	58	23	19	100
Middlesex	52	31	17	100
Oxford	47	29	24	100
Perth	44	24	32	100
Waterloo	56	11	33	100
Wellington	41	18	41	100
SHEEP Study Area	48	27	25	100

Where nitrogen was applied, approximately 88% of the responses indicated that the application occurred during the spring (Table 28). Six percent of the fields had nitrogen fertilizer applied during the fall, while a further 6% of the applications were divided between spring and fall. There was relatively little variation by county with respect to the timing of nitrogen applications. Practices appear somewhat different in Essex County in that it had the lowest percentage of spring application (72%) and the highest proportion of applications divided between spring and fall (22%).

Table 28

Timing of Nitrogen
Fertilizer Applications
Percent Response by Category

County/Region	Spring %	Fall %	Spring & Fall %
Brant	97	3	0
Elgin	91	6	3
Essex	72	6	22
Haldimand-Norfolk	94	3	3
Hamilton-Wentworth	95	0	5
Huron	91	7	2
Kent	86	1	13
Lambton	83	6	11
Middlesex	87	7	6
Oxford	83	9	8
Perth	94	4	2
Waterloo	94	2	4
Wellington	82	9	9
Sweep Study Area	88	6	6

Throughout the whole study area half (49%) of the responses indicated that nitrogen was applied by broadcasting (Table 29). A further 34% indicated that nitrogen was applied through the planter. In 6% of the responses, nitrogen application was made using a sprayer. Eight percent of the fields had nitrogen injected. Overall, 3% of the nitrogen was applied by different methods "Other" than those above.

Broadcasting and application of nitrogen through the sprayer showed values throughout the counties which were close to those for the study area as a whole. Sprayers were used most often in Waterloo Region (10%) and least often in Essex (2%) and Lambton (1%). Kent and Brant counties reported the highest use of the nitrogen injection method with 20% and 17% respectively.

Table 29

Method of Nitrogen Application
Percent Response by Category

County/Region	Broadcast %	Through Planter %	Sprayer %	Injected %	Other %
Brant	50	28	5	17	0
Elgin	43	35	7	14	1
Essex	61	21	2	8	8
Haldimand-Norfolk	47	36	6	10	1
Hamilton-Wentworth	41	43	7	9	0
Huron	48	42	6	1	3
Kent	51	25	4	20	0
Lambton	64	27	1	5	3
Middlesex	44	30	8	7	11
Oxford	48	33	8	9	2
Perth	45	43	6	5	1
Waterloo	42	36	10	10	2
Wellington	53	39	5	2	1
SWEEP Study Area	49	34	6	8	3

5.7.3 Phosphorus Fertilizer

Phosphorus has been identified as the main nutrient of interest in the improvement of Great Lakes water quality. While both nitrogen and phosphorus contribute to excessive growth of aquatic plants, nitrogen moves freely between the atmosphere and the water. This cycling of nitrogen makes control impractical. Phosphorus, however, can be controlled. Reduced phosphate detergents, improved sewage treatment facilities and urban storm water management are all methods of reducing phosphorus inputs to the Great Lakes. International Joint Commission

studies (IJC, 1978) estimated that as much as 45 to 55 percent of the phosphorus reaching the Great Lakes comes from agricultural sources. Thus, the thousands of individual decisions made on farms together influence the quality of the water in streams, rivers and lakes. A number of questions were asked regarding the application of phosphorus fertilizers, the timing and the method of application.

Table 30 shows that in the SWEEP study area, 48% of responses indicated that phosphorus fertilizer was applied based on experience. Twenty-eight percent of the applications were made on the basis of a soil test performed within the previous year. Phosphorus fertilizers were not used on 24% of the study area fields. The highest percentage of application based on a soil test were reported in Huron (45%), Middlesex (35%), and Perth (33%). The lowest reported percentages for application of phosphorus based on a soil test occurred in Waterloo (15%).

Table 30

Basis for Applying
Phosphorus Fertilizer
Percent Response by Category

County/Region	Based on Experience %	Based on Soil Test %	Not Used %
Brant	81	16	3
Elgin	62	16	22
Essex	45	22	33
Haldimand-Norfolk	39	19	42
Hamilton-Wentworth	44	19	37
Huron	45	45	10
Kent	40	36	24
Lambton	63	21	16
Middlesex	43	35	22
Oxford	50	31	19
Perth	47	33	20
Waterloo	51	15	34
Wellington	43	16	40
Sweep Study Area	48	28	24

The overwhelming proportion of phosphorus fertilizers (83%) were applied in the spring (Table 31). Thirteen percent of the responses indicated fall application, while 4% of the responses indicated applications were made both in the spring and in the fall. In Essex County, 25% of the responses indicated phosphorus was applied in the fall. In Brant County, fall applications of phosphorus were made in 20% of the fields.

Table 31

Timing of Phosphorus Applications
Percent Response by Category

County/Region	Spring %	Fall %	Spring & Fall %
Brant	80	20	0
Elgin	95	5	1
Essex	74	25	1
Haldimand-Norfolk	94	4	2
Hamilton-Wentworth	100	0	0
Huron	78	19	3
Kent	78	17	5
Lambton	82	15	4
Middlesex	83	12	6
Oxford	84	11	5
Perth	86	11	4
Waterloo	90	10	1
Wellington	77	15	8
Sweep Study Area	83	13	4

Table 32 shows that in the 13 counties studied by SWEEP, two methods accounted for 95% of the phosphorus applications: 48% of the responses indicated that broadcasting was used, while 47% of the responses indicated that phosphorus had been applied through the planter. The remaining 5% was split among application by sprayer (1%), by injection (2%), and by some "other" means (2%).

In Haldimand-Norfolk, of the 239 responses regarding how phosphorus was applied, 10% indicated that phosphorus was injected. The highest rates of application through the planter occurred in Oxford and Perth where 60% of the responses in these counties fell in that category. The highest rates of application by broadcasting occurred in Essex County where 72% of the responses in the county showed that broadcasting was used to apply phosphorus fertilizer.

Table 32

Means of Applying Phosphorus
Percent by Category

County/Region	Broadcast %	Through Planter %	Sprayer %	Injected %	Other %
Brant	42	54	5	0	0
Elgin	47	50	1	0	2
Essex	72	28	0	0	0
Haldimand-Norfolk	34	56	0	10	0
Hamilton-Wentworth	36	59	4	1	0
Huron	57	42	0	0	1
Kent	58	40	1	1	0
Lambton	63	32	0	1	3
Middlesex	43	42	1	2	13
Oxford	38	60	0	1	0
Perth	38	60	0	1	0
Waterloo	45	49	3	3	0
Wellington	49	48	1	1	0
Sweep Study Area	48	47	1	2	2

6.0 FUTURE USE OF THE DATA

6.1 Other Investigations

This report outlines the findings of the study conducted to establish base line conditions of cropping, tillage and land management practices in thirteen counties of Southwestern Ontario. While the report gives a thorough overview of the results, not all relationships among the data have yet been explored. It is the intent of the Working Committee that further exploration of the data will be made and reported upon. Several such areas of investigation exist. One area will be the relationships between cropping, tillage and crop residue. Another would be a closer examination of the manure and fertilizer use data, in co-operation with the environmental agencies participating in SWEEP, looking particularly at relationships with water quality data.

6.2 Soil Loss Calculations

From earlier studies of erosion and sediment transport by the Lands Directorate of Environment Canada and by the Ontario Institute of Pedology, data on the slope-length factor and the soil erodibility factor of the Universal Soil Loss Equation (USLE) are available (Wischmeier and Smith, 1983). These two sets of data are compatible and can be combined with the survey results to estimate soil loss in the study area.

One of the major influences on the design of the study was the need to isolate the management unit (the field) upon which farmers make

decisions and operate their tillage and planting equipment. Thus, data was collected on a field by field basis, and the field location was recorded on a sketch. In the following section, an illustration of the potential use of the data will be provided with reference to a specific case.

For each sample site selected in the present survey, the following set of information is available:

Agricultural Systems Class 1981 - ARI*
Agricultural Systems Class 1986 - present study
Crop in each field 1981 - ARI*
Crop in each field 1986 - present study
USLE Soil Erodibility (K) Factor
USLE Slope-Length (LS) Factor
USLE Rainfall (R) Factor

*ARI Agricultural Resources Inventory

A common identifier is stored with the survey data, which allows access to all of the soils data recorded by the Ontario Institute of Pedology.

The following farm sketch (Figure 19) illustrates the data available for the Universal Soil Loss Equation calculation.

For convenience we can label the fields A through E. The questionnaire provides the area of each field and the 1986 crop. The 1981 crop is extracted from the field notes associated with the Agricultural Resource

Inventory conducted by the Soil and Water Management Branch of OMAF. From the interview and the mapping we can compile the worksheet which follows. This information can be rearranged to simplify the calculation of the Universal Soil Loss Equation. The USLE is calculated as the product of all its factors. Crop/cover values are substituted for each crop or land use system. The practice factor is associated with management practices designed to reduce erosion. These may be needed to account for changes from conventional tillage to conservation tillage practices, or to account for soil loss reductions gained by cross-slope tillage etc.

Figure 19 - Farm Sketch

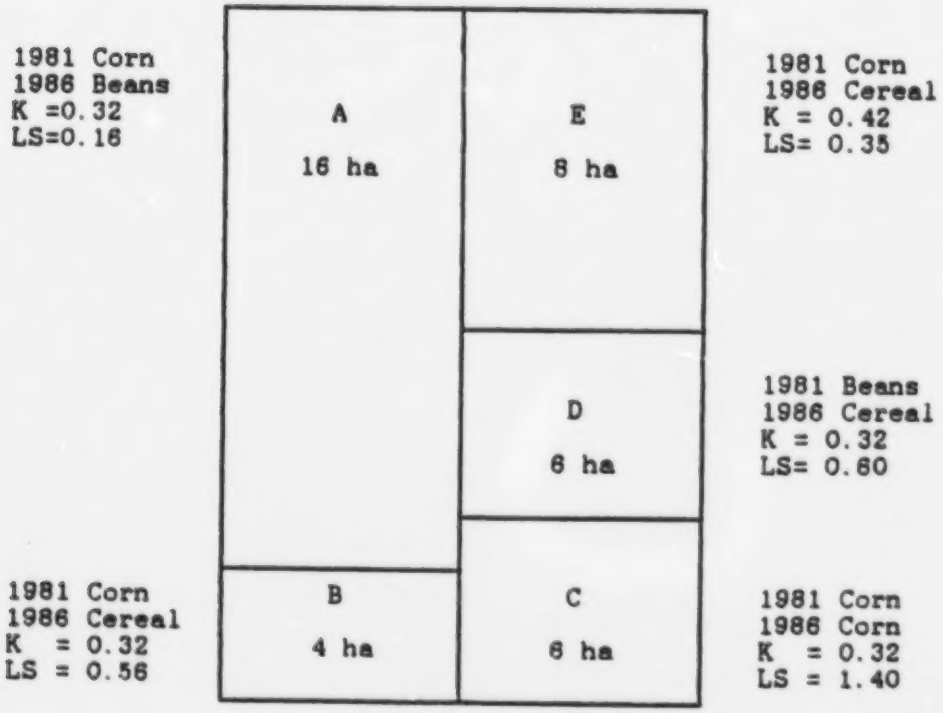


Figure 20

Universal Soil Loss Equation Worksheet

Field	Area of Field Hectares	Rainfall Factor	Soil K Factor	Slope/ Length Factor
Field A	16	110	0.32	0.16
Field B	4	110	0.32	0.56
Field C	6	110	0.32	1.40
Field D	6	110	0.32	0.60
Field E	8	110	0.42	0.35

1981

	Crop 1981	Cover Factor 1981	Soil Loss Tonnes/Ha	Total Soil Lost Tonnes
Field A	Corn	0.50	6.3	101
Field B	Corn	0.50	22.1	88
Field C	Corn	0.50	55.3	332
Field D	Beans	0.50	23.7	142
Field E	Corn	0.50	18.1	145
			20.2	809

1986

	Crop 1986	Cover Factor 1986	Soil Loss Tonnes/Ha	Total Soil Lost Tonnes
Field A	Beans	0.50	6.3	101
Field B	Cereals	0.25	11.1	44
Field C	Corn	0.50	55.3	332
Field D	Cereals	0.25	11.8	71
Field E	Cereals	0.25	9.1	73
			15.5	621

The multiplication of the factors gives a measure of tonnes of soil loss per hectare per year. Multiplying this by the area of the field gives the number of tonnes of soil lost from the field annually. If this operation is performed for each field on the farm and the total losses are summed, the number of tonnes of soil lost from the farm on average each year can be found.

When this calculation is performed using the 1981 crop information, a total of 809 tonnes of soil are lost each year. This corresponds to an average rate of loss of 20.2 tonnes per hectare, although the losses in individual fields can be much greater. In performing the calculation for 1986, it can be seen that beans and cereal grains now predominate. This time using the 1986 crops and plugging their cover factors into the equation, 50% reductions occur in the outputs from fields B, D, and E. The changes in cropping result in soil loss being reduced to 621 tonnes. The decrease (188 tonnes) corresponds to a 23% reduction in soil loss.

A number of scenarios can be tested to see the effects of various implementation measures. For example if the corn in field C, which is steeply sloping, could be cultivated across the slope a reduction of 99 tonnes of soil loss could be obtained. However, the field still is eroding at 38.8 tonnes per hectare. No-till techniques have been successfully used by some farmers in Ontario for a number of years. If no-till were used in this situation, what reductions would result? The practice factor associated with no-till is 0.12. Applying this to the corn crop in field C one would obtain a total soil loss of 39 tonnes at an annual rate of 6.6 tonnes per hectare. Clearly there are numerous trade-offs which can be evaluated with respect to cropping, tillage and conservation management practices.

The interview data and the associated set of information derived from the soil loss mapping has a larger potential. The mapping procedure provides an estimate of the area of homogenous landscape units based on the R, K, and LS factors of the USLE. These were factors are physically based and change slowly over time. The interview data provides a representative

set of information which shows how cropping, tillage, fertilization and management vary. Using the interview data from this survey and matching it with the soil loss data for the interview locations, one can derive a relationship which statistically describes how the two sets of data relate. Combining the two sets of information allows the extrapolation of the information from the representative units to the whole study area.

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Appendix A

Membership of the Land Management and Cropping Practices Working Group

Membership of the Working Group included:

- Rodger Thompson, Agriculture Canada (Chairman)
- Galen Driver, Ontario Ministry of Agriculture and Food
- Greg Wall, Agriculture Canada
- Dell Coleman, Environment Canada
- Art Bos, Ontario Ministry of the Environment
- Bob van den Broek, Ontario Ministry of Agriculture and Food
- Jane Sadler-Richards,(former member) Ontario Ministry of Agriculture and Food
- Don Blackburn, University of Guelph

Appendix B

SWEEP Tillage and Cropping Practices Survey

1986

CONFIDENTIAL

SWEEP PERSONAL INTERVIEW

COVER SHEET

County _____ Township _____

Concession _____ Lot _____

Owner's Name _____

Mailing Address:

Street/R.R./Box: _____

City/Town : _____

Postal Code : _ _ _ _ _ _

Telephone : Area _ _ _ Number _ _ _-_ _ _ _

if not operator then

Operator's Name: _____

Mailing Address:

Street/R.R./Box: _____

City/Town : _____

Postal Code : _ _ _ _ _ _

Telephone : Area _ _ _ Number: _ _ _ - _ _ _ _

Interviewer Name: _____

Interview Number: _ _ _ _ Photo No. _____

Contact Record

Call	Date	Result
1st		
2nd		
3rd		

SWEEP TILLAGE & CROPPING PRACTICES SURVEY
1988

Interviewer, please fill in:

Interview Number ..... |_|_|_|_|

County number ..... |_|_|

Township number ..... |_|_|_|

CROPPING PRACTICES

1. Workable Acres

	Field A	B	C	D	E	F	G	H

(-8 Not Applicable / -9 No Response)

2. Crops 1988

	Field A	B	C	D	E	F	G	H

00 None
01 Grain Corn
02 Silage Corn
03 Soybeans 20-30" Rows
04 Soybeans 7" Rows
05 White Beans
06 Fall Cereal or Oil Seed
07 Spring Cereal or Oil Seed
08 Forage
09 Tobacco
10 Field Vegetables
11 Small Fruits or Market Garden crops
12 Not Appropriate
13 Other
14 No response

If "Other" please specify

Field _____ Crop _____

Field _____ Crop _____

3. Crop Rotation

	Field A	B	C	D	E	F	G	H

1 Row crops only
2 Row crops and cereals
3 Row crops, cereals and forage
4 Row crops and forage
5 Cereals and forage
6 Forage and pasture
8 Not Applicable
9 No Response

4. Plowdown?

	Field A	B	C	D	E	F	G	H

1 = Yes 2 = No 8 = Not Applicable 9 = No Response

5. Strip cropping

	Field A	B	C	D	E	F	G	H

1 = Yes 2 = No 8 = Not Applicable 9 = No Response

Field

	A	B	C	D	E	F	G	H
6. Field Border?								

1 = Yes 2 = No 8 = Not Applicable 9 = No Response

Field

	A	B	C	D	E	F	G	H
7. Border Width (ft)								

(-8 = Not Applicable, -9 = No Response)

8. Change cropping? 1 Yes 2 No 9 No response

9. Major reasons for cropping change:

1 Reduce erosion
2 Poor soil structure
3 Improve Yields
4 More plowdown
5 Changed crops, enterprise or land base
6 Reduced tillage
7 Economic Reasons
8 Better crop rotation
9 Changed fertilizer, herbicide or pesticide use
10 No Response

TILLAGE PRACTICES

Field

	A	B	C	D	E	F	G	H
10. Tillage Machine (2)								

0 None
1 Moldboard Plough
2 Modified Moldboard
3 Disc/coulter chisel plough
4 Chisel plough
5 Tandem disc & harrows
6 Cultivator
7 Other
8 Not Applicable
9 No response

if "Other", specify
Field ___ Machine _____
Field ___ Machine _____
Field ___ Machine _____

Field

	A	B	C	D	E	F	G	H
11. When tilled?								

1 Oct. - Dec.
2 Mar. - May
3 Jun. - Sept.
8 Not Applicable
9 No response

Field

	A	B	C	D	E	F	G	H
12. Tillage Depth								

1 1- 4 inches
2 5- 6 inches
3 7-10 inches
4 greater than 10 inches
8 Not Applicable
9 No response

Field

A B C D E F G H

13. Direction

1 Up and down the slope
2 Across the major slope
3 On the contour
4 Direction not related to slope
7 Other
8 Not Applicable
9 No response

SEEDBED PREPARATION

Field

A B C D E F G H

14. Seedbed Tillage

0 None
1 Cultivator
2 disc & harrows
3 Harrows
4 Cultipacker/Roller
5 Mulch tiller
7 Other
8 Not Applicable
9 No Response

if "Other", specify
Field ___ Machine _____
Field ___ Machine _____
Field ___ Machine _____

Field

A B C D E F G H

15. Times Tilled?

0 None
1 Once
2 Twice
3 Three times
4 Four or more
8 Not Applicable
9 No response

Field

A B C D E F G H

16. Why repeated

1 Water ponding
2 Poor Drainage
3 Rain
4 Surface Cracking
5 Not fine enough
7 Other

If other please specify.

_____

_____

Field

1 2 3 4 5 6 7 8

17. Time of year?

1 Oct. - Dec.
2 Mar. - May
3 Jun. - Sept.
8 Not Applicable
9 No response

18. Why did tillage change? ☐

1 Didn't Change Tillage
2 Reduce production costs
3 Reduce erosion/get more residue
4 Maintain or build soil structure
5 Improve Yields
6 Changed crops/equipment
7 Problems with stoniness

If the answer is "Other", please specify reason

Reason _____
_____

PLANTING

	Field A	B	C	D	E	F	G	H
19. Planter?	☐	☐	☐	☐	☐	☐	☐	☐

1 Regular Row Crop Planter
2 Regular Seed Drill
3 Row crop planter, designed or modified for heavy residue conditions
4 Seed Drill designed or modified for heavy residue
5 Broadcast
6 Transplanter
7 Other
8 Not Applicable
9 No response

if "Other" please specify,
Field _____ Planter _____
Field _____ Planter _____

	Field A	B	C	D	E	F	G	H
20. Direction of Planting	☐	☐	☐	☐	☐	☐	☐	☐

1 Up and down the major slope
2 Across the major slope
3 Round and round the field
4 On the contour
5 Direction not related to slope
7 Other
8 Not Applicable
9 No response

If "Other", please specify
Field _____ Direction _____
Field _____ Direction _____

LAND MANAGEMENT PRACTICES

21. Response 1 Yes, privately financed
2 Yes, grant assisted
3 Yes, both of the above
4 Not present
9 No Response

Water erosion control structures	☐
Ditch or streambank stabilization	☐
Permanently vegetated buffer strips along ditches or stream banks	☐
Tree windbreaks	☐
Reforestation (within the last 5 years)	☐

22. Acres drained

Field

	A	B	C	D	E	F	G	H
(acres) Systematic								
Random								
Natural								

(-8 Not Applicable / -9 No Response)

FERTILIZER USE

Field

A	B	C	D	E	F	G	H

23. Apply manure?
1 = Yes 2 = No 8 = Not Applicable 9 = No Response

Field

A	B	C	D	E	F	G	H

24. Tons applied
(-8 Not Applicable/ -9 No Response)

25. How is it stored? 1 solid, 2 semi-solid, 3 liquid

Field

A	B	C	D	E	F	G	H

26. How Applied?

1 Spreader and tractor
2 Spread with tank
4 Inject into soil
5 Irrigate
8 Not Applicable
9 No response

if other, please specify
Field _____ Method _____
Field _____ Method _____
Field _____ Method _____

Field

A	B	C	D	E	F	G	H

27. When applied?

1 Fall
2 Spring
3 Summer
4 Winter
5 Fall and Spring
6 Fall, Spring and Summer
7 All year
8 Not Applicable
9 No Response

Field

A	B	C	D	E	F	G	H

28. How soon incorporated?

1 Same day
2 Within 1 - 3 days
3 More than 3 days
4 Spread on forage
8 Not Applicable
9 No response

Field

	A	B	C	D	E	F	G	H
29. Nitrogen Fertilizer?								

1 Yes based on experience 3 Not Used 9 No response
2 Yes based soil test 8 Not Applicable

Field

	A	B	C	D	E	F	G	H
30. When applied?								

1 Spring 3 Both spring 8 Not Applicable
2 Fall and fall 9 No response

Field

	A	B	C	D	E	F	G	H
31. How applied								

1 Broadcast, 2 through planter, 3 with sprayer, 4 injected
7 Other 8 Not Applicable 9 No Response

Field

	A	B	C	D	E	F	G	H
32. Phosphorus Fertilizer?								

1 Yes based on experience 3 Not Used 9 No response
2 Yes based soil test 8 Not Applicable

Field

	A	B	C	D	E	F	G	H
33. When applied?								

1 Spring 3 Both spring 8 Not Applicable
2 Fall and fall 9 No response

Field

	A	B	C	D	E	F	G	H
34. How applied								

1 Broadcast, 2 through planter, 3 with sprayer, 4 injected
7 Other 8 Not Applicable 9 No Response

GENERAL INFORMATION

35. Years farming this parcel |_|_|

36. Size of entire operation? acres |_|_|_|_|

37. Major Enterprise? |_|

0 Beef 5 Cash Crop
1 Dairy 6 Fruit or Vegetables
2 Swine 7 Tobacco
3 Poultry 8 Mixed
4 Sheep 9 No Response

38. Livestock or poultry numbers:

Beef _ _ _ Dairy _ _ _ Swine _ _ _ _ Sheep _ _ _ _
Hens _ _ _ _ _ Turkeys _ _ _ _ _

39. Age group of operator? ☐

1 15 - 19, 3 25 - 34, 5 45 - 54, 7 65 - 69
2 20 - 24, 4 35 - 44, 6 55 - 64, 8 70+

40. Had erosion/conservation info from: 1 Yes, 2 No, 9 No Response

- Meetings ☐
- OMAF News ☐
- Farm Publications ☐
- Radio or television ☐
- Books or journals ☐
- Research Institutes or Universities ☐

SWEEP Personal Interview Questionnaire

The parcel of land for this survey is

Concession _____

Lot _____

I have an aerial photograph of this parcel with me and perhaps together we can outline the boundaries just so we're both talking about the same place! ... Thank you.

Would you show me the boundaries of the fields that you have in this site this year? (Make any changes to sketch)

CROPPING PRACTICE

1. How many workable acres are there in each field?

2. What crops will you harvest from these fields this year? If the answer is "Other", please specify the crop and field .

3. If you use a crop rotation, what combination of crops is present in the rotation?

4. Did any of the fields have a plowdown crop such as red clover with your other crop?

5. Did you use any strip cropping this year? That's where you grow a strip of forage, a strip of row crop or cereals, then a strip of forage and so on across a slope or a field?

6. In any of these fields, did you plant a border of cereals or forage around a row crop such as corn or beans?

7. If you did, about how many feet wide was the border?

8. For this particular piece of land, have you changed your cropping practices during the last five years?

9. If yes, what are the major reasons you changed?

TILLAGE PRACTICES

10. For each field, what was the first tillage machine or combination of machines that you used after harvesting the crop in 1985? Maximum two machines per field. If the answer is "Other", please specify the field as well as the machines used.

11. What time of year did you do this tillage?

12. What was the deepest you tilled each field?

13. Many fields in Ontario have a hill or slope to them. For each of the fields, what direction did you travel in relation to the major slopes on last pass over the field?

SEEDBED PREPARATION

14. To prepare the seedbed for the crop you expect to harvest in 1986, what tillage machines did you use in each field? Maximum 3 separately or in combination per field.

If the answer is "Other", please specify the field and the machine used.

IF THE ANSWER FOR ALL FIELDS IS NONE, BEGIN THE SECTION ON PLANTING

15. How many times did you till each field with the machines you just mentioned?

16. If you repeated any operations, why was it necessary?

17. What time of year did you do these operations?

18. If you have changed any of your seedbed tillage in the last five years, why did you change?

PLANTING

19. When you planted the crop in each field, what type of planter did you use? If the answer is "Other", please specify the field and the planter.

20. For each field, will you tell me the direction in which you planted the rows? If your answer is "other", please specify the direction and the field.

LAND MANAGEMENT PRACTICES

21. You have in front of you a list of different land management practices besides tillage and cropping that you may have in place. If you want I can clarify what we mean by these. If you have any, would you show me its location on the sketch.

22. How many acres of systematic, random or natural drainage do you have in each field?

FERTILIZER USE

23. Did you apply manure or sewage sludge to your fields?

24. How many tons did you apply in each field?

25. In what form was the manure stored?

26. How did you apply the manure? If the answer is "Other", please specify the method.

27. What time of year did you apply the manure?

28. How soon after application was the manure incorporated into the soil?

29. Did you apply commercial nitrogen fertilizer to your fields?

30. What time of year did you apply the fertilizer?

31. How did you apply this fertilizer?

32. Did you apply commercial phosphorus fertilizer to your fields?

33. What time of year did you apply the fertilizer?

34. How did you apply this fertilizer?

GENERAL INFORMATION

35. For this particular parcel of land, how many years have you farmed it?

36. What is the total number of workable acres you are farming? Please include rented land, if you have any.

37. What would you say your major farming enterprise is?

38. If there are livestock or poultry, what is the maximum number you would have at a time?

39. Into which of the following groups does your age fall?

40. Can you tell us whether you have received any information regarding soil conservation or erosion control from any of the following sources in the last year?

CONCLUDING REMARKS

Well, that's all the questions I have for you!

Do you have any questions you'd like to ask me? ... If you have any questions later on just give us a call.

One thing further, we are interested in doing some measurements of crop residues next spring just before planting. Someone from our study may contact you about that early next year.

Thank you for your help. We certainly appreciate your taking time to answer these questions.